The Report of The Joint Federal-Provincial Inquiry Commission into Safety in Mines and Mining Plants in Ontario

Volume 2
Statistics and Research Reports

towards safe production

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Introduction

This volume of our Report contains the research papers and legal opinion which were prepared on our behalf. Because of the time constraints facing the Commission and because of the complexity of many of the issues raised before the Commission, we retained the services of persons with recognized expertise. A number of these persons were asked to prepare research papers. These papers, and the legal opinion we received with respect to the legislative and administrative arrangement pertaining to the safety of uranium miners and mining plant workers, added greatly to our understanding of the issues. These papers provide a necessary background to the main body of our Report.

Contents

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An update of statistics found in the Report of the Royal Commission on the Health and Safety of Workers in Mines

January 1981

The Commission retained Harry Shannon, Assistant Professor, Occupational Health Program, McMaster University to up-date the statistics produced in the Report of the Royal Commission on the Health and Safety of Workers in Mines – 1976, and to report on the accident data base in the Ontario mining industry. Professor Shannon holds a Ph.D. in statistics and has specialized in the area of occupational health and safety statistics. His thesis was on A Statistical Study of 2,500 Consecutive Reported Accidents in a Automobile Factory. Dr. Shannon obtained his Ph.D. at the University of London, England.

Introduction

The report of the Ham Commission presented a variety of statistical data on mining accidents in Ontario, mainly in the form of tabulations and graphs. Whilst some of the information had been derived to answer specific questions addressed to that Commission, it was felt that the data should be updated to achieve an overview of accident performance in the last few years, as well as to determine any changes that might have occurred. In addition, a number of extra tabulations were made and will be presented.

Various sources of data were used. (A) Public records of fatal mining accidents were abstracted and coded. They were analysed by computer to enable multiple cross-tabulations to be easily obtained. (B) A letter from the Commission was sent to safety supervisors of most mining companies in the province asking them to supply information on hours worked, numbers and rates of compensable accidents and numbers of fatal accidents for each year from 1974 to 1979 (as well as 1980 to date) and for each operation of the company. Companies also supplied information on personnel categories in their different operations. (C) The (Statistics Division) of the Workmen's Compensation Board (WCB) was asked to provide some information on the causes of accidents, as well as the distributions of accidents by age and by length of employment.(D) A number of tables were taken from briefs of the Ontario Ministry of Labour–the information had been sought independently, but at the time of writing was not available and it was not felt worthwhile to pursue other sources. (E) Additional sources were contacted as and when required–see footnotes to tables.

The order of data presentation will follow that of the Ham Commission Report, and each table or graph will be accompanied by a commentary. A major point to note is that the distributions of many variables for all miners are not available. Inferences are thus difficult to draw because rates cannot be calculated, although such data as are available will be used. It should also be remarked that direct comparisons with the Ham Commission data are not always possible because of differences in definitions used currently in the various sources. The tabulations reported by Ham were often accompanied by the 'expected' figures. These were generally based on the best available data, but it may be questioned whether they were valid. (For example, the distribution of experience of the provincial workforce was based on that of INCO.) We have preferred not to use such information, but have compared distributions for 1975-80 with those obtained for the earlier period covered by the Ham Commission.

Three other comments should be made mainly regarding the fatal accidents. Firstly, some pieces of information were missing, so the numbers shown occasionally add to less than the total number of accidents. Secondly, the numbers, from a statistical point of view, are relatively small so a lack of statistical significance should not necessarily be interpreted as proof that no relationship exists. Finally, and most importantly, it will be noted that figures are not always consistent from table to table. This is due to problems with the data base and differences between the various sources used. Comments on this are made in a separate report.

Results

The rates of fatal accidents for 1969-79, based on the number of fatalities per million hours worked, are shown numerically in Table 1 and graphically in Figure 1. An unweighted least squares regression analysis showed a slight decline from 1969 to 1979. By July of 1980, when the Commission was set up, there had been 15 fatalities in the year. An estimate of the number of hours worked gave a rate of about 0.4-0.5 fatalities per million hours, which was significantly higher than would be expected. (The predicted value, based on the regression line, was 0.153 with a 95% confidence interval of 0.02 to 0.29.) Since July there have been fewer fatal accidents and the number of fatalities for the year was 19. Using an estimate of the hours worked of 70 million, the rate for 1980 was roughly 0.27, still higher than expected based on previous years.

Table 2 shows fatality rates for miners in Ontario, U.S.A. and Sweden. Whilst there are a number of problems in making a direct comparison they show that Ontario's performance compares favourably, except with British coal mines.

An interprovincial comparison of fatal accident rates is shown numerically in Table 3 for 1969-79 and graphically in Figure 2. Ontario generally has had lower rates than the three other provinces–British Columbia, Manitoba and Quebec. The variations in the rates for B.C. and Manitoba presumably reflect the smaller numbers of fatalities and hence the greater propensity for the rates to be affected by random fluctuations in the data. (Comparability of the data is unclear–e.g., whether all employees or only underground workers are included.)

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*Figures 1-4 are on pages 13-15, followed by Tables 1-27 on pages 15 through to 37.

The trend in the rates of lost-time injuries in the province is shown numerically in Table 4 and graphically in Figure 3. The rate had been increasing from 1972 to 1975 but the trend was subsequently reversed and there was a decline each year to 1979. Preliminary data for 1980 suggest that the rate has risen again. (The lost-time injuries include disabling industrial disease, rather than just traumatic injury, but this should have little, if any, effect on the patterns found).

Letters were sent by the Commission to those mining companies in the province that presented submissions. They requested information on accident rates for different operations for each year from 1975 on. Table 5 shows a summary of the information obtained, grouping companies by the main type of metal mined. The overall fatality rate was 0.17 per million hours worked, the highest rate, 0.30, occurring in the uranium mines.

The fatality rate for selected industries from 1975 to 1978 is shown in Figure 4. It is important to note that the overall rate for each industry includes occupationally-caused diseases (e.g. silicosis or various types of cancer). The proportion of such deaths in the logging industry, although, is probably much lower than in mining–so the accident fatality rate in logging, up to 0.60, is considerably higher than in mining 0.21. However, the rates for construction, 0.16, and manufacturing, 0.038, are lower (and since a few deaths will be due to diseases, the difference will be greater than it appears). The figure for manufacturing is lower than that derived from Annual Reports of the Industrial Accident Prevention Association. However, these include initial *and* resettled claims, so cannot be used for comparison.)

Records of 87 fatalities from 1975 to 1980 kept in the files of the Mine Health and Safety Branch of the Ontario Ministry of Labour were examined. (For details, see footnote to Table 6.) Table 6 shows the distribution of these miners by personnel category and, for comparison, the data for 1965-74. There was little change between the two periods–although it should be noted that the 88% of fatalities from 1965-74 occurring to unskilled or semi-skilled persons and group leaders was much higher than expected based on their proportion in the mining population. Thus the slight reduction in the proportion of accidents occurring to this group may be seen as encouraging, although it is unclear as to the extent to which this was due to any change in the percentage of this group in the mining population. Moreover, our best evidence suggests that only about 60% of the miners are in this category.

The age distribution (Table 7) shows a higher proportion of fatalities occurring to younger men (aged less than 30) during 1975-80 than during 1965-74.

However, this change is not significant (X^2 on 7 d.f. = 7.06, p = 0.42). Unfortunately, we cannot consider whether the (small) change may be due to a change in the age distribution of the mining population, since no recent data are seemingly available.*

It is our impression that the population may have aged; if so, the increase of 10% in the proportion of fatalities to miners aged under 30 will be an underestimate of the 'true' increase for the age group. (Such an increase has implications in terms of training and experience.) By contrast the percentage of compensable injuries occurring to younger miners was lower in 1979 than in 1974–30% against 43%.

A programme of 'modular training' has been in effect since about 1978. One way to examine its impact is to consider the age distribution of miners suffering fatal accidents. If the training is effective it should reduce the accident rate in younger miners. Table 7b shows that the percentage of fatal accidents in the youngest group fell between 1975-78 and 1979-80. Whilst the numbers are statistically small, this provides some (albeit weak) evidence of a benefit from the programme.

The pattern of fatalities by years of experience at the company of last employment (Table 8a) shows a decrease in the proportion of fatalities occurring to short-service (less than 5 years) miners. The trend is not significant (X^2 on 2 d.f. = 2.59, p = 0.27). Once again, the actual distribution for the mining population is unknown, so it is difficult to comment on the change. One point can be made: since younger employees generally have shorter service it is surprising that the proportion of fatalities to younger miners increased while the proportion to shorter service employees decreased. This suggests perhaps a high level of turnover among older employees.

The distribution of length of experience with last company was examined from 1979-80 for evidence of an effect of modular training (Table 8b). Just as the youngest men had a declining proportion of fatal accidents, so the percentage of accidents to men with short service fell–suggesting some benefit from the training.

The Ham Commission report commented on the "clear indication that unskilled and semi-skilled persons with less than five years' experience at

* Statistics Canada conducts a regular survey of the workforce sampling 56,000 households throughout the country. Their unpublished data might have been used, but rough calculations suggest that their sample would include a total of about 150 Ontario miners–too few to obtain an accurate age-distribution.

the company of last employment are at much higher risk of suffering a fatal injury than are other workers''. Tables 8 and 9 show that the proportion of deaths occurring among this group has fallen substantially–but once again it is not known if changes in the distributions of these variables for all miners have or have not had any effect on this.

The proportion of fatalities from 1975-80 due to accidents on the day shift, from 7 to 3, increased by 13% compared with 1965-74 while there was a corresponding decline in the proportion of fatalities on the afternoon/evening shift, from 3 to 11 (Table 10). The proportion on the night shift was almost constant. (The change in pattern was not significant, X^2 on 2 d.f. = 4.62, p = 0.10).

When the proportion of deaths of men with less than five years' experience with the company of last employment was examined for each shift (Table 11) it was found that there had been a substantial decline in the proportions for the day and night shifts. However, the proportion had risen for the afternoon/evening shift and was higher than the night shift. Once again, comment is difficult because of the lack of denominator data, although it is worth noting that at some companies the night shift has been abolished.

The proportion of fatalities occurring to men working alone or not alone for each shift is shown in Tables 12 and 13. For the day and night shifts there was little or no change from 1965-74 to 1975-80; for the afternoon/evening shift there was an increase, but the numbers are too small to draw any firm conclusion.

There was little difference in the distributions of experience with last company of fatalities of miners working alone and those not working alone (Table 14). The increase in the proportions of accidents occurring to men with longer service has already been noted.

The types of fatal accidents were classified using their descriptions in the Ministry of Labour files (Tables 15). The categorization was that of the comparable table in the Ham Commission report. However, because of ambiguities and overlapping categories, it was not always clear that a consistent classification could be achieved, and in 3 cases accidents could not be assigned to one of the 'types'. The most frequent type was 'Fall of Person' which accounted for roughly one third of all fatalities, 11% more than had been the case from 1965-74. By contrast, the proportion of 'Falls of Ground' was down by nearly 10%. The distribution of other categories remained roughly constant.

Fatalities occurring within various metal groups are shown in Table 16. Although the nickel group had the highest proportion (48%) this was lower than expected, based on the number of hours worked. By contrast, the proportion of fatalities among shaft sinkers and mining contractors was much higher than expected (15%).

When the data are categorised by whether the miners killed were employees of owner operated establishments or were 'outsiders' (Table 17) it is found that the observed rate was over four times higher for the outsiders. A statistical test of the observed and expected frequencies of fatalities in each category showed highly significant differences. (X^2 on 1 d.f. = 20.13, $p < 0.001$. The calculations assume that the distribution of hours worked was similar in 1980, for which data are not yet available.)

Lighting was mentioned in the reports only 8 times (Table 18). On three occasions there was 'no lighting', but this was not necessarily a factor in the accident. A jury recommended improved lighting on four occasions. It is unclear as to how many other accidents there were in which inadequate lighting played a part. Whilst the fact that no mention was made of illumination may suggest that its influence was irrelevant, this may not have always been the case.

Alcohol as a factor in accidents was mentioned once (Table 19). It was not, however, the victim but a crew member in whom its presence was detected.

The use or non-use of safety belts as a factor in accidents was mentioned 24 times (Table 20). On 21 occasions their non-use was mentioned in the report and this was probably a relevant factor in the accident. (Lack of consistency in the reports makes it difficult to judge exactly when the non-use contributed to the fatality.)

There were four occasions where more than one person was killed as a result of a single accident (Table 21). A total of 10 people died in such incidents. The tabulations above have treated each individual separately, rather than making classifications by accident. Had the latter been done there would have been little difference in the results.

As noted earlier companies contacted by the Commission supplied details of hours worked and compensable accidents. The data were summarized by metal group and are shown in Table 22. (Detailed data by company are shown below.) The highest rate was that for nickel mining companies, whose

63.8 accidents per million hours was roughly 50% higher than the second highest rate (43.6 for 'Miscellaneous Industrials'). The lowest rate was 5 times lower–12.7 for copper mines.

Further data on compensable accidents were obtained from the WCB. Table 23 shows the 'principal causes' of such accidents in 1979 based on classification by the Mines Accidents Prevention Association of Ontario (MAPAO). The two major causes listed were 'slips and falls' and 'overexertion', which each accounted for about one quarter of the total.

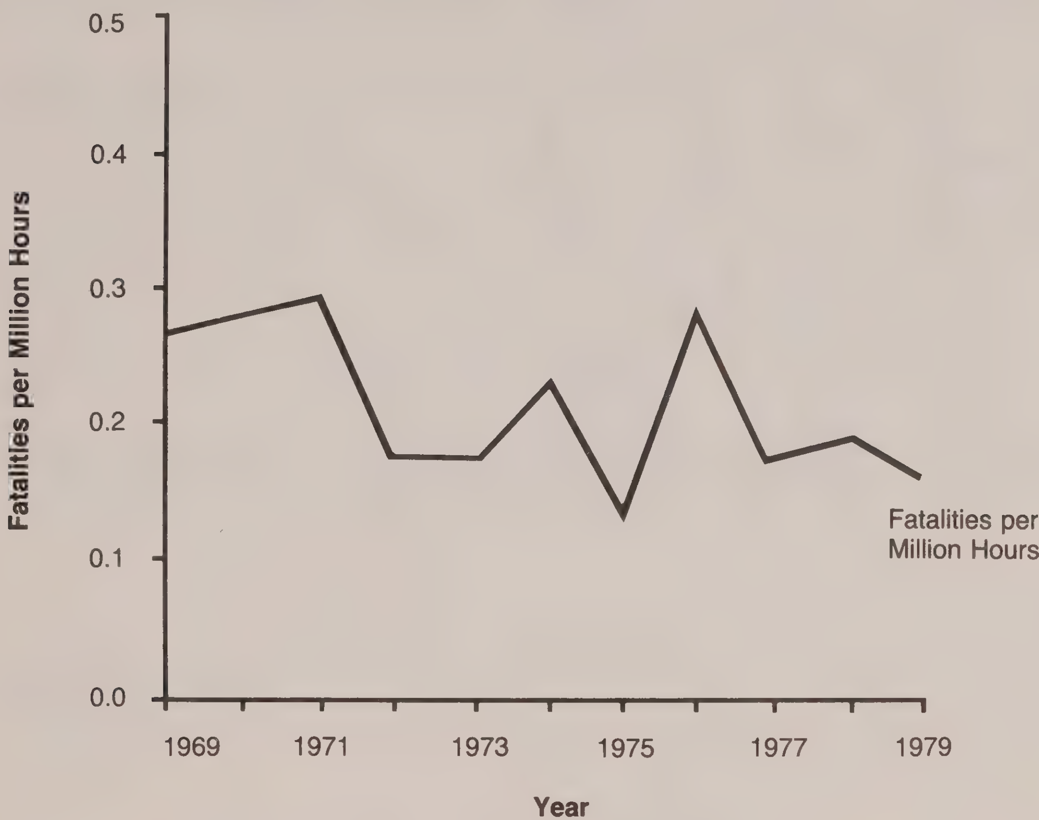
The age distribution of compensable injury victims (Table 24) shows a decline in the percentage of accidents occurring to younger miners and first compensated in 1979 compared with 1974. This trend is statistically significant (X^2 on 9 d.f. = 205.2, $p < 0.001$) and is stronger than the corresponding shift in fatal accidents (shown in Table 7b).

Similarly, the distributions of years of experience for miners with injuries for which compensation was first paid in 1974 and 1979 (Table 25) shows a small drop in the percentage occurring to those with under 5 years' service with the company–from 47% in 1974 to 39% in 1979. The difference in trend shown in the table is statistically significant (X^2 on 2 d.f. = 46.3, $p < 0.001$).

The two final tables (Tables 26 & 27) are based on the information supplied by various companies to the Commission. They detail the performance of each company (in some cases broken down by operation) with respect to fatal and compensable accidents during 1975-80. For comparison, the change since 1970-74 (the period covered by the Ham Commission report) is shown.

Figure 1

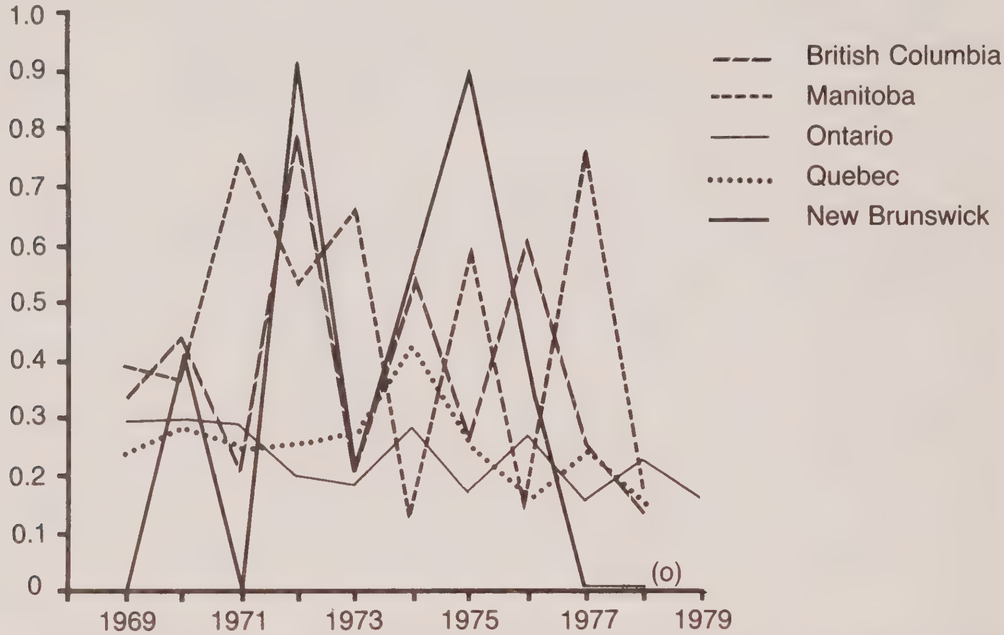
Accidental fatalities in Ontario mines 1969 to 1979



Source: Ontario Ministry of Labour, Occupational Health and Safety Division. *Brief of the Ontario Ministry of Labour to the Joint Federal-Provincial Inquiry into Safety in Mines and Mining Plants in Ontario.*

Figure 2

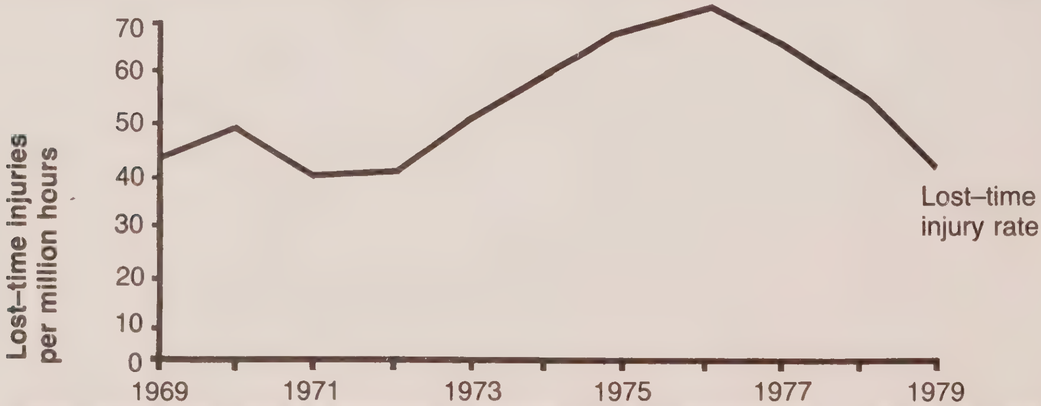
Inter-provincial comparison of fatal inquiry rates (1969-1979)



Derived from Ministry of Labour, Occupational Health and Safety Division *Appendices to the Brief of the Ontario Ministry of Labour to the Select Committee on Ontario Hydro Affairs, July 23, 1980*, Vol. I, Table 4B, Page 9

Figure 3

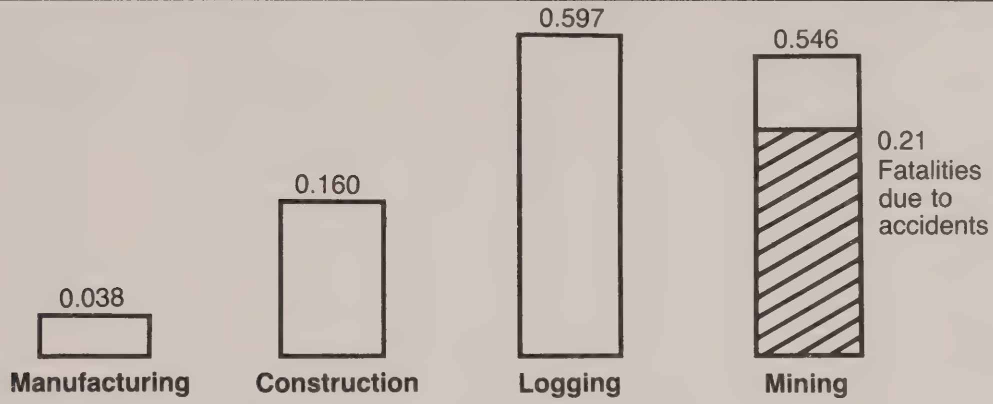
Lost–time injury rate in Ontario mines 1969 to 1979



Source: Workmen's Compensation Board, obtained through Ontario Ministry of Labour. See Table 4 of this report.

Figure 4

Fatality rate in selected industries (1975-1978)



Source: Ontario Ministry of Labour, Occupational Health and Safety Division. *Appendices to the Brief of the Ontario Ministry of Labour to The Select Committee on Ontario Hydro Affairs, July 23, 1980*, Vol I., Page 16

Table 1

Employment and accidental fatalities in Ontario mines (1969-1980)

Year	Employment in million hours	Number of fatalities	Fatality rate (a)
1969	76.7	21	0.27
1970	84.8	24	0.28
1971	89.6	26	0.29
1972	78.6	13	0.17
1973	72.1	12	0.17
1974	74.9	17	0.23
1975	76.8	10	0.13
1976	80.0	22	0.28
1977	75.8	13	0.17
1978	62.4	12	0.19
1979	57.3 (b)	9	0.16
1980	N.A.	19	N.A.

(a) Fatalities per million hours worked. N.A. — Not available
(b) Provisional data.

Source: Ontario Ministy of Labour, Occupational Health and Safety Division. Brief of the Ontario Ministry of Labour to the Joint Federal-Provincial Inquiry into Safety in Mines and Mining Plants in Ontario. November 20, 1980.

Table 2

A comparison of fatal injury rates in Ontario, U.S.A., and Sweden

		Fatal Injury Rates		
Year	Ontario	U.S.A.	Sweden	Britain[3]
1974	0.28	NA[1]	0.68	0.12
1975	0.17	0.28	0.25	0.15
1976	0.27	0.26	0.64	0.12
1977	0.16	0.31	0.77	0.10
1978	0.23	0.30	1.10	0.16
1979	0.16	0.25[2]	NA	0.11

Source: Ontario Ministry of Labour, Occupational Health and Safety Division. *Appendices to the Brief of the Ontario Ministry of Labour to the Select Committee on Ontario Hydro Affairs, July 23, 1980*, Vol. I, Page 11.

1. N.A. — Not available
2. Projected data, based on Jan-Sept. 1979 figures.
3. Coal mining only.

Table 3

An inter-provincial comparison of fatal injury rates (1969-1979)

Year	British Columbia	Manitoba	Ontario	Quebec	New Brunswick
1969	0.33	0.39	0.29	0.24	0.00
1970	0.44	0.37	0.30	0.28	0.42
1971	0.21	0.75	0.29	0.25	0.00
1972	0.79	0.53	0.20	0.25	0.92
1973	0.23	0.67	0.18	0.27	0.21
1974	0.54	0.13	0.28	0.42	0.11
1975	0.27	0.59	0.17	0.26	0.89
1976	0.61	0.14	0.27	0.15	0.36
1977	0.26	0.76	0.16	0.24	0.00
1978	0.14	0.18	0.23	0.15	0.00
1979			0.16		

Source: Ontario Ministry of Labour, Occupational Health and Safety Division. *Appendices to the Brief of the Ontario Ministry of Labour to The Select Committee on Ontario Hydro Affairs, July 23, 1980.*, Vol. 1, Page 9

Table 4

Employment and lost-time injuries in Ontario mines, 1969-79

Year	Employment in million hours	Number of lost-time injuries	Rate of injuries per million hours
1969	76.7	3444	44.9
1970	84.8	4152	49.0
1971	89.6	3665	40.9
1972	78.6	3281	41.7
1973	72.1	3719	51.6
1974	74.9	4615	61.4
1975	76.8	5257	68.5
1976	80.0	5749	71.9
1977	75.8	5082	67.0
1978	62.4	3527	56.5
1979	57.3[a]	2476	43.2

Source: Workmen's Compensation Board, obtained through Ontario Ministry of Labour.
a) Provisional Data.

Table 5

Fatal injuries by metal group summary (1975 to Oct. 31, 1980)

Metal Group	Employees (Oct. 31, 1980)	Total no. fatalities	Total no. hours	Rate per million hours	Rank (highest to lowest)
Gold	2947	7	28,444,658	0.25	2
Iron	2170	2	24,732,676	0.08	4
Miscellaneous industrials	627	0	6,531,041	0.00	6
Copper	4028	3	41,909,652	0.07	5
Silver	237	0	2,168,668	0.00	6
Uranium	4717	11	36,936,243	0.30	1
Nickel	19949	35	199,599,664	0.18	3
All Groups	34675	58	340,332,602	0.17	

Source: Commission Study, data supplied by companies contacted by Commission. For details by company, see Table 26.

Table 6

Distribution of fatalities by personnel category, 1975 to 1980

Personnel category	Observed no.	Fatalities[a] proportion	Ham[b] Study proportion	Change since 1974
Unskilled/semi-skilled Group Leaders	71	.82	.88	−.06
Skilled Trades	9	.10	.05	+.05
Supervision/Management	7	.08	.07	+.01
Engineering/Technical	0	Nil	Nil	Nil
Clerical	0	Nil	Nil	Nil
Total	**87**	**1.00**	**1.00**	

a From 1975 to 1980 inclusive, 87 fatalities. Includes 6 occurring at metallurgical plants owned by non-mining companies.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976,* Table 34, p. 132. For the period 1965 to 1974.

Table 7a

Age as a factor in fatalities

Age	Observed fatalities[a] number	%	Ham Commission[b] results number	%	Since 1974 % change
< 20	5	6	5	2	+4
20-24	17	20	40	19	+1
25-29	14	16	24	11	+5
30-34	8	9	23	11	−2
35-39	11	13	27	13	0
40-44	10	11	25	12	−1
45-49	6	7	29	14	−7
50-54	8	9	11	5	+4
55-59	6	7	18	8	−1
≥ 60	2	2	11	5	−3
Total	87	100	213	100	

a From 1975 to 1980 inclusive.

b *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976,* Table 35, p. 133, from 1965-1975.

Table 7b

Distribution of fatalities by age from 1979 to October 31, 1980

Age	No. cases[a] 1979-80	%	No. cases[b] Ham Study	%	% Change since 1974	% Change from period 1975-78 to 1979-80
≤ - 24	5	19	45	21	−2	−9
25 - 34	7	27	47	22	+5	+2
35 - 44	7	27	52	24	+3	+4
45 - 54	3	12	40	19	−7	−6
55+	4	15	29	14	+1	+8
	26	100	213	100		

a Source: Ministry of Labour, Mining Health and Safety Branch, *Accident Analysis Report,* for cases occurring in 1979-1980.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 34, p. 132. For cases occurring between 1965 and 1974.

Table 8a

Fatalities related to years of experience at company of last employment

Years of experience (where known)	Observed No.	Fatalities[a] Proportion	Ham Commission[b] results No.	Ham Commission[b] results Proportion	% Change since 1974
< 1	17	.22	54	.28	− 6
1 - 5	22	.29	65	.34	− 5
> 5	38	.49	73	.38	+11
Total	77	1.00	192	1.00	

a From 1975 to 1980 inclusive.
Derived from Mining Health and Safety Branch, Ministry of Labour *Monthly Fatality Reports* and fatality files.

b For five year period 1970-1974.
Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976, Table 36, p. 134.

Table 8b

Fatalities related to years of experience at company of last employment, 1979 and 1980

Years of experience (where known)	Fatalities[a] No.	%	Fatalities from[b] Ham Study No.	%	% Change since 1974	% Change from period 1975-78 to 1979-80
< 1	2	8	54	28	−20	−21
1 - 5	9	36	65	34	+ 2	+11
> 5	14	56	73	38	+18	+10
Total	25	100	192	100		

a Source: Ministry of Labour, Mining Health and Safety Branch, *Accident Analysis Report* for cases occurring in 1979 and 1980.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976,* Table 36, p. 134. For cases occurring from 1970 to 1974.

Table 9

Fatalities by category of personnel and years of experience with company of last employment

		Observed Proportion with indicated[a] years of experience				Percent change since 1974[b] Ham Commission Data			
Personnel	All	<1	1-5	≤5	>5	<1	1-5	≤5	>5
Unskilled/ semi-skilled	1.00	.27	.27	.54	.47[c]	− 5	− 8	−13	+14[c]
Other	1.00	0	.38	.38	.62	−12	+16	+ 4	− 4

a For period to 1980 inclusive, 77 valid cases.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 37, p. 134.

c Rounding error.

Table 10

Fatalities by shift worked

Hours of shift	Observed fatalities[a] No.	%	% change since[b] Ham Study
7 a.m. to 3 p.m.	57	68	+13
3 p.m. to 11 p.m.	13	15	−12
11 p.m. to 7 a.m.	14	17	−1
Total	84	100	

a From 1975 to end of October 1980.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 38, p. 135.

Table 11

Fatalities by shift: proportion with less than five years of experience with company of last employment

Shift	Total cases	Cases less than 5[a] yrs. experience at com. of last employ. No.	%	% change since[b] Ham Study
7 a.m. to 3 p.m.	50	20	40	−20
3 p.m. to 11 p.m.	12	8	67	+13
11 p.m. to 7 a.m.	12	7	58	−23
Total	74	35	n.a.	

a 1975 to 1980 inclusive. Out of 74 cases whose shift and experience were known, 35 had less than 60 months experience with company of last employment.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 39, p. 135.

Table 12

Fatalities by shift of persons working alone and not alone

Hours of shift	Working alone* Observed Cases[a] No.	%	% Change Since[b] Ham Study	Not working alone Observed Cases No.	%	% Change Since Ham Study
7 a.m. to 3 p.m.	11	20	− 3	45	80	+ 3
3 p.m. to 11 p.m.	5	38	+20	8	62	−20
11 p.m. to 7 a.m.	4	29	0	10	71	0
All shifts	20	24	+ 1	63	76	− 1

*Includes cases not assigned a partner or to a crew, or the victim had a partner or was part of a crew but was alone at time of accident.

a From 1975 to 1980 inclusive.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 40, p. 136.

Table 13

Fatalities by shift of persons working alone and persons not working alone

Hours of shift	Working alone* Observed Cases[a] No.	%	% Change Since[b] Ham Study	Not working alone Observed Cases No.	%	% Change Since Ham Study
7 a.m. to 3 p.m.	11	55	−1	45	71	−16
3 p.m. to 11 p.m.	5	25	+4	8	13	−15
11 p.m. to 7 a.m.	4	20	−3	10	16	− 1
All Shifts	20	100		63	100	

*Includes cases not assigned a partner or to a crew, or the victim had a partner or was part of a crew but was alone at time of accident.

a From 1975 to 1980 inclusive.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 40, p. 136.

Table 14

Fatalities: proportion of total by experience with company of last employment and those working alone or not alone

Years Experience with company	Working alone: Observed Cases No.[a]	%	% Change Since[b] Ham Study	Not working alone: Observed Cases No.[a]	%	% Change Since[b] Ham Study
1	5	26	− 8	12	21	−5
1 to 5	4	21	− 9	18	31	−4
5	10	53	+17	27	47	+9
Total	19	100		57	100[c]	

a From 1975 to 1980 inclusive, 76 known cases.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 43, p. 137.

c Figures do not add to 100 due to rounding error.

Table 15

Fatalities by kind of accident

Type of accident	Proportions of all[a] fatalities	% change since[b] Ham Commission
Fall of Ground	.155	− 9.4
Fall of Person	.321	+10.5
Fall of Object	.107	− 2.4
Haulage	.214	+ 1.2
Run of Muck	.095	+ 2.9
Explosives	.071	+ 1.9
Drowning	.012	− 1.1
Burns	.012	− 1.1
Suffocation	0	− 2.3
Electrocution	.012	+ 0.2
Fatigue	0	− 0.5
Total	1.00*	

a From 1975 to 1980 inclusive, 84 fatalities could be matched to the Ham Commission Accident Types.

b James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table 44, p. 138, Period 1965-1974.

*Figures do not sum due to rounding error.

Table 16

Fatalities by metal groups, 1975 to end of 1980

Metal Groups	Frequency	Percent	Number hours worked 1975-1979	Rate per million hours	Expected percent and no. based on no. hours worked (%)	(number)
Gold	8	11.6	26,946,400	0.30	8.2	5.6
Nickel[b]	33	47.8	169,250,000	0.19	51.4	35.5
Copper	3	4.3	39,432,200	0.08	12.0	8.3
Uranium	12	17.4	30,694,400	0.39	9.3	6.4
Iron	2	2.9	34,659,900	0.06	10.5	7.3
Silver and Magnesium	0	0.0	5,606,300	0.00	1.7	1.2
Misc. Industrials	0	0.0	7,840,700	0.00	2.4	1.6
Diamond Drillers	1	1.4	3,516,900	0.28	1.1	0.7
Shaft Sinkers and Mining Contractors	10	14.5	11,181,000	0.89	3.4	2.3
Sub Total	69	100.0*	329,127,800	0.22	100.0	69.0
Other Contractors[c]	6	n.a.	n.a.	n.a.	n.a.	n.a.
Other Metallurgical Plants	6	n.a.	n.a.	n.a.	n.a.	n.a.
Total	87					

Source: Ministry of Labour Mining, Health and Safety Branch, *Monthly Fatality Reports* and fatality files, 1975 to the end of 1980, Commission Study.

a From MAPAO Injury Statistics, 1975-1979, total hours worked for all operating companies in that group. Hours worked in 1980 not available.

b Does not include 2 killed in airplane crash.

c Includes electrical, plumbing, construction, painting, etc.

*Does not sum due to rounding error.

Table 17

Fatalities by employer type

Category	Observed[a] frequency	%	Observed[b] rate	Expected[b] frequency	Total hours[b] worked 1975-1975
Owner and Operator	58	66.7	0.18	65.9	314,429,900
Shaft Sinkers Mining Contractors Diamond Drillers	11	12.6	0.75	3.1	14,697,900
Other Contractors	12	13.8	n.a.	n.a.	n.a.
Non Mining Metallurgical Plants	6	7.9	n.a.	n.a.	n.a.
Total	87	100.0[c]			329,127,800

a Commission study of Ministry of Labour, Mining Health and Safety Branch fatality files, 1975 to end of 1980.

b Based on million hours worked from 1975 to 1979 inclusive, for mining companies and contractors, Source: MAPAO 1979 injury statistics.

c Does not add to 100 due to rounding error.

Table 18

Fatalities where lighting noted*

Category	Frequency	Percent
No Light	3	37.5
Light in Area	1	12.5
Jury Recommend Improved Lighting	4	50.0
Total	8	100.0

Source: Commission Study

*Where mentioned in Ministry of Labour, Mining Health and Safety Branch, fatality reports.

Table 19

Fatalities where alcohol noted*

Category	Cases
In crew member	1
In victim	0
Total	1

*Where mentioned in Ministry of Labour, Mining Health and Safety Branch fatality reports.

Table 20

Fatalities by safety belt/lanyard use by types of mining operation*

Category	Hooked up	Not hooked up	Total
Mines Underground	2	9	11
Mines Surface	0	6	6
Metallurgical Works	1	6	7
Total	3	21	24

Source: Commission Study.

*Where use or non-use mentioned in Ministry of Labour, Mining and Safety Branch, fatality reports.

Table 21

Multiple fatalities

No. persons involved	Frequency	Total persons
2	2	4
3*	2	6
Total	4	10

*One 3-person fatality occurred in a metallurgical plant, the other multiple fatality incidents occurred at underground mines.

*Commission Study.

Table 22

Compensable injuries by metal group summary (1975 to Oct. 31, 1980)

Metal group	Employees (Oct. 31, 1980)	Total no. comp. injuries	Total no. hours worked	Rate per million hours	Rank (highest to lowest)
Gold	2947	680	28,444,658	23.9	5
Iron	2170	538	24,732,676	21.8	6
Miscellaneous Industrials	627	285	6,531,041	43.6	2
Copper	4028	534	41,909,652	12.7	7
Silver	237	89	2,168,668	41.0	3
Uranium	4717	1394	36,936,243	37.7	4
Nickel	19949	12742	199,599,664	63.8	1
All Groups	34675	16262	340,332,602	47.8	

Source: Commission Study, data supplied by companies contacted by Commission, see Table 27.

Table 23

Principal causes of accidents during 1979

Principal causes	Number of injuries	Percentage of total
Slips and falls	574	27.9
Overexertion	525	25.5
Striking, struck by objects	262	12.7
Caught between objects	168	8.2
Rock falls	150	7.3
Falling objects	143	6.9
Flying objects	116	5.6
Extremes of temperature	32	1.6
Other	88	4.3
Total	2058	100.0

Source: Workmen's Compensation Board Program Planning and Statistical Services. Data classified by and obtained from Mines Accident Prevention Association of Ontario.

Table 24

Mining compensable injuries by age, 1974 and 1979

	1974		1979	
Age group	No. of injuries	%	No. of injuries	%
<20	196	6.5	78	2.8
20-24	604	20.0	356	12.7
25-29	516	17.0	413	14.7
30-34	383	12.6	360	12.8
35-39	274	9.0	281	10.0
40-44	255	8.4	250	8.9
45-49	292	9.6	269	9.6
50-54	241	8.0	303	10.8
55-59	159	5.3	236	8.4
60+	109	3.6	262	9.3
Sub Total	3029	100.0	2808	100.0
Unknown	1451		98	
Total	4480		2906	

Source: WCB Claims for disability with first compensation payment in 1974 or 1979.

Table 25

Mining compensable injuries by experience at company of last employment

	1974		1979	
Years of experience	No. of claims	%	No. of claims	%
< 1	959	24.8	567	20.4
1 - 5	877	22.7	522	18.7
> 5	2028	52.5	1695	60.9
Sub-Total	3864	100.0	2784	100.0
Unknown	616		122	
Total	4480		2906	

Source: WCB Claims for disability with first compensation payment in 1974 or 1979.

Table 26

Fatality experience by metal group and company from 1975 to Oct. 31, 1980[1]

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total fatalities from 1975 to Oct. 31, '80	Rate per[2] million hours worked	Rates in[3] Ham Study	Rate change since Ham Study
Gold					
Campbell Red Lake	379	0	0	0.35	−0.35
Dickenson	NA	NA	NA	0.87	NA
Dome	680	0	0	0.14	−0.14
Kerr Addison	360	1	0.22	0.60	−0.38
Willroy (Macassa Div.)	273	1	0.41	0.87	−0.46
Pamour Porcupine–					
Schumacher Div.	562	2	0.35	0.25	+0.10
Pamour No. 1 & 2	474	3	0.59	0.42	+0.17
Pamour No. 3 ('77-'80)	117	0	0	NA	NA
Ross ('76-'80)	102	0	0	0	0
Total Gold	2947	7	0.25	0.42	−0.17
Iron					
Adams Mine	440	0	0	0	0
Algoma Steel Corp.-					
Algoma Ore Div.	738	2	0.24	0	+0.24
Griffith Mine	508	0	0	0	0
Sherman	484	0	0	0	0
Total Iron	2170	2	0.08	0.06	+0.02
Miscellaneous Industrials					
Canada Talc	17	0	0	0	0
Canadian Rock Salt	253	0	0	0.87	−0.87
Domtar – Sifto Salt	252	0	0	0	0
Indusmin – Silica Div.					
Killarney	37	0	0	0	0
Midland	68	0	0	0	0
Total Misc. Industrials	627	0	0	0.23	−0.23

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total fatalities from 1975 to Oct. 31, '80	Rate per[2] million hours worked	Rates in[3] Ham Study	Rate change since Ham Study
Copper					
Mattabi Mines	406	0	0	0.59	−0.59
Noranda – Geoco Div.	689	3	0.41	0.34	+0.07
Selco Mining – South Bay	119	0	0	0	0
Texasgulf Metals	2490	0	0	0.14	−0.14
UMEX-Thierry ('76-'80)	324	0	0	NA	NA
Total Copper	4028	3	0.07	0.23	−0.16
Silver					
Agnico Eagle	116	0	0	1.36	−1.36
Canadaka	49	0	0	NA	NA
Teck Corp.–Silverfields Div.	72	0	0	1.43	−1.43
Total Silver	237	0	0	1.40	−1.40
Uranium					
Denison	1961	6	0.38	0.27	+0.11
Madawaska ('77-'80)	373	1	0.36	NA	NA
Rio Algom	2383	4	0.22	0.50	−0.28
Total Uranium	**4717**	**11**	**0.30**	**0.39**	**−0.09**
Nickel					
Falconbridge					
East Mine	—	0	0	0.72	−0.72
Falconbridge Mine	639	3	0.53	0.32	+0.21
Fecunis Mine (to 1978)	—	1	1.34	0.80	+0.54
Fraser Mine ('77-'80)	128	1	2.22	NA	NA
HBO Mine	—	0	0	0	0
Lockerby Mine	181	0	0	NA	NA
Onaping Mine ('79-'80)	91	0	0	NA	NA
Strathcona Mine	508	2	0.41	0.41	0
Total Falconbridge Mines	1547	7	0.49	NA	NA

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total fatalities from 1975 to Oct. 31, '80	Rate per[2] million hours worked	Rates in[3] Ham Study	Rate change since Ham Study
Falconbridge Mill	140	1	0.99	0	+0.99
Fecunis Mill (to 1977)	—	0	0	0	0
Hardy Mill (1975 only)	—	0	0	0	0
Strathcona Mill	111 Approx.	0	0	0	0
Falconbridge Smelter	327	0	0	0.35	−0.35
Total Falconbridge Reduction	542	1	0.16	NA	NA
Falconbridge Electrical	79	0	0	0	0
Falconbridge Mech.	366	0	0	0.36	−0.36
Lockerby Electrical ('78-'80)	19	0	0	NA	NA
Lockerby Mech. ('78-'80)	98	0	0	NA	NA
Onaping Electrical	100	0	0	0	0
Onaping Mechanical	375	0	0	0	0
Total Falconbridge Services	1037	0	0	NA	NA
Diamond Drilling	86	0	0	NA	NA
Sundry	728	2 (Plane crash)	0.29	NA	NA
Total Falconbridge	3934	10	0.27	0.23	+0.04
INCO					
Clarabelle Open Pit	56	0	0	0	0
Coleman Mine	276	0	0	0	0
Copper Cliff N. Mine	20	2	0.46	0.16	+0.30
Copper Cliff South Mine	670	1	0.18	0	+0.18
Crean Hill Mine (to 1979)	—	0	0	0.42	−0.42
Creighton Mine	1548	5	0.34	0.37	−0.03
Frood #3 Mine	1201	6	0.51	NA	NA
Garson Mine	917	3	0.37	0.21	+0.16
Kirkwood Mine (1975 only)	—	0	0	1.16	−1.6
Levack Mine[4]	1190	2	0.17	0.27[5]	−0.10
Little Stobie Mine	170	0	0	NA	NA
McCreedy West Mine ('77-'80)	184	0	0	NA	NA
Shebandowan	284	2	0.79	0	0
Stobie #7 Mine	929	1	0.12	NA	NA
Total INCO Mines	7445	22	0.29	NA	NA

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total fatalities from 1975 to Oct. 31, '80	Rate per[2] million hours worked	Rates in[3] Ham Study	Rate change since Ham Study
Clarabelle Mill	296	0	0	0	0
Copper Cliff Mill	353	0	0	0	0
Frood/Stobie Mill	180	0	0	0	0
Levack Mill (to 1979)	—	0	0	0	0
Copper Cliff Smelter	2623	0	0	0.03	−0.03
Matte Processing	421	0	0	0	0
Copper Cliff Nickel Refinery	344	0	0	0	0
Copper Cliff Copper Refinery	947	1	0.10	0	+0.10
Port Colbourne Nickel Refinery	863	0	0	0	0
Iron Ore Recovery Plant	529	1	0.19	0	+0.19
Total INCO Reduction	6556	2	0.03	NA	NA
Divisional Shops	512	0	0	NA	NA
Field Maintenance (to 1978)	—	0	0	NA	NA
Maintenance Construction (to '78)	—	0	0	NA	NA
Central Maintenance Force ('79-'80)	471	0	0	NA	NA
Transportation	343	1	0.30	NA	NA
Utilities and Power	197	0	0	NA	NA
Process Technology	491	0	0	NA	NA
Administration	NA	0	0	NA	NA
Safety and Plant Protection	NA	0	0	NA	NA
Purchasing and Warehousing	NA	0	0	NA	NA
Total INCO Services	2014	1	0.04	NA	NA
Total INCO	16015	25	0.15	0.15	0
Total Nickel	19949	35	0.18	0.16	+0.02
Total All Companies	34675	58	0.17	NA	NA

1. Companies contacted by the Joint Federal-Provincial Inquiry Commission into Safety in Mines and Mining Plants in Ontario.

2. Fatality rate per million hours worked for 1975 to October 31, 1980.

3. James M. Ham *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table D.5., Average rates for 1970 to 1974.
4. Includes McCreedy West for 1975, 1976 only.
5. Rates includes McCreedy West for 1970-1974.

NA Not available

$$\text{Fatality Rate} = \frac{\text{Total fatalities} \times 1{,}000{,}000 \text{ (hours)}}{\text{Total number hours worked for that company or category}}$$

Table 27

Compensable injury experience by metal group and company from 1975 to Oct. 31, 1980[1]

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total Comp.[2] injuries for 1975 to Oct. 31, 1980	Rate per[3] million hours worked	Rates in[4] Ham Study	Rate change since Ham Study
Gold					
Campbell Red Lake	379	58	14.9	11.6	+ 3.3
Dickenson	NA	NA	NA	13.9	NA
Dome	680	225	32.3	39.3	− 7.0
Kerr Addison	360	87	18.8	17.0	+ 1.8
Willroy (Macasaa Div.)	273	138	57.3	58.5	− 1.2
Pamour Procupine– Schumacher Div.	562	72	12.7	31.6	−18.9
Pamour No. 1 & 2	474	71	13.9	18.1	− 4.2
Pamour No. 3 (77-80)	117	11	10.8	NA	NA
Ross (76-80)	102	18	15.5	64.2	−48.7
Total Gold	2947	680	23.9	28.2	− 4.3
Iron					
Adams Mine	440	82	18.9	26.5	− 7.6
Algoma Steel Corp.– Algoma Ore Div.	738	200	24.1	20.8	+ 3.3
Griffith Mine	508	58	9.0	14.5	− 5.5
Sherman	484	198	35.0	31.1	− 3.9
Total Iron	2170	538	21.8	22.7	− 0.9

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total comp.[2] injuries for 1975 to Oct. 31, '80	Rate per[3] million hours worked	Rates in[4] Ham Study	Rate change since Ham Study
Miscellaneous Industrials					
Canada Talc	17	23	72.2	39.4	+32.8
Canadian Rock Salt[2]	253	173	66.5	58.2	+ 8.3
Domtar – Sifto Salt[2]	252	69	27.0	24.0	+ 3.0
Indusmin – Silica Div.					
Killarney	37	1	2.5	NA	NA
Midland	68	19	29.1	NA	NA
Total Misc. Industrials	627	285	43.6	33.2	+10.4
Copper					
Mattabi Mines	406	77	20.3	24.8	– 4.5
Noranda – Geco. Div.	689	209	28.7	20.0	+ 8.7
Selco Mining – South Bay	119	21	21.4	26.7	– 5.3
Texasgulf Metals	2490	142	5.1	5.3	– 0.2
UMEX – Thierry (76-80)	324	85	39.2	NA	NA
Total Copper	4028	534	12.7	14.4	– 1.7
Silver					
Agnico Eagle	116	22	26.3	55.9	–29.6
Canadaka	49	43	76.4	NA	NA
Teck Corp. – Silverfields Div.	72	24	31.2	54.3	–23.1
Total Silver	237	89	41.0	55.1	–14.1
Uranium					
Denison	1961	610	38.6	19.8	+18.8
Madawaska (77-80)	373	106	37.8	NA	NA
Rio Algom	2383	678	37.0	21.5	+15.5
Total Uranium	4717	1394	37.7	20.7	+17.0

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total comp.[2] injuries for 1975 to Oct. 31, '80	Rate per[3] million hours worked	Rates in[4] Ham Study	Rate change since Ham Study
Nickel					
Falconbridge[2]					
East Mine	—	9	37.7	23.7	+14.0
Falconbridge Mine	639	273	48.6	26.2	+22.4
Fecunis Mine (to 1978)	—	39	52.5	33.7	+18.8
Fraser Mine (77-80)	128	37	82.1	NA	NA
HBO Mine	—	7	29.8	30.2	− 0.4
Lockerby Mine	181	84	47.7	NA	NA
Onaping Mine (79-80)	91	16	71.6	NA	NA
Strathcona Mine	508	410	83.8	35.1	+48.7
Total Falconbridge Mines	1547	875	61.8	NA	NA
Falconbridge Mill	104	12	11.9	5.5	+ 6.4
Fecunis Mill (to 1977)	—	6	25.7	25.8	− 0.1
Hardy Mill (1975 only)	—	0	0	24.3	−24.3
Strathcona Mill	111 approx.	26	21.6	12.9	+ 8.7
Falconbridge Smelter	327	172	43.2	26.2	+17.0
Total Falconbridge Reduction	524	216	33.6	NA	NA
Falconbridge Electrical	79	15	19.8	5.7	+14.1
Falconbridge Mechanical	366	103	33.1	19.2	+13.9
Lockerby Electrical (78-80)	19	0	0	NA	NA
Lockerby Mechanical (78-80)	98	11	37.4	NA	NA
Onaping Electrical	100	22	22.6	13.0	+ 9.6
Onaping Mechanical	375	141	41.0	29.3	+11.7
Total Falconbridge Services	1031	292	33.9	NA	NA
Diamond Drilling	86	33	66.3	NA	NA
Sundry	728	50	7.2	NA	NA
Total Falconbridge	3934	1466	40.0	21.5	+18.5

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total comp.[2] injuries for 1975 to Oct. 31, '80	Rate per[3] million hours worked	Rates in[4] Ham Study	Rate change since Ham Study
INCO[2]					
Clarabelle Open Pit	56	33	35.3	36.1	− 0.8
Coleman Mine	276	434	142.6	176.3	−33.7
Copper Cliff North Mine	20	524	120.4	7.8	+112.6
Copper Cliff South Mine	670	462	82.0	107.0	−25.0
Crean Hill Mine (to 1979)	—	211	80.8	85.8	− 5.0
Creighton Mine	1548	1672	115.2	78.8	+36.4
Frood #3 Mine	1201	1313	112.6	NA	NA
Garson Mine	917	603	74.8	82.8	− 8.0
Kirkwood Mine (1975 only)	—	11	43.2	78.4	−35.2
Levack Mine[5]	1190	1498	128.7	130.4[6]	− 1.7
Little Stobie Mine	170	220	139.7	NA	NA
McCreedy West Mine (77-80)	184	70	72.3	NA	NA
Shebandowan	284	176	69.6	95.4	−25.8
Stobie #7 Mine	929	813	95.9	NA	NA
Total INCO Mines	7445	8040	105.4	NA	NA
Clarabelle Mill	296	124	51.1	59.0	− 7.9
Copper Cliff Mill	353	132	37.8	74.8	−37.0
Frood/Stobie Mill	180	131	77.0	47.7	+29.3
Levack Mill (to 1979)	—	137	129.8	135.7	− 5.9
Copper Cliff Smelter	2623	449	28.9	54.9	−26.0
Matte Processing	421	116	25.1	NA	NA
Copper Cliff Nickel Refinery	344	97	28.9	26.5	+ 2.4
Copper Cliff Copper Refinery	947	637	66.6	93.2	−26.6
Port Colbourne Nickel Refinery	863	623	53.4	34.8	+18.6
Iron Ore Recovery Plant	529	119	23.1	35.0	−11.9
Total INCO Reduction	6556	2565	43.8	NA	NA

Metal groups and company	Average no. employees (Oct. 31, 1980)	Total comp.[2] injuries for 1975 to Oct. 31, '80	Rate per[3] million hours worked	Rates in[4] Ham Study	Rate change since Ham Study
Divisional Shops	512	150	39.5	NA	NA
Field Maintenance to 1978)	NA	78	50.4	NA	NA
Maintenance Construction (to 78)	NA	102	87.4	NA	NA
Central Maintenance Force (79-80)	471	60	53.1	NA	NA
Transportation	343	95	28.2	NA	NA
Utilities and Power	197	26	13.6	NA	NA
Process Technology	491	1	1.1	NA	NA
Administration	NA	50	5.6	NA	NA
Safety and Plant Protection	NA	92	24.5	NA	NA
Purchasing and Warehousing	NA	17	11.5	NA	NA
Total INCO Services	2014	671	23.9	NA	NA
Total INCO	16015	11276	69.2	62.9	+ 6.3
Total Nickel	19949	12742	63.8	54.8	+ 9.0
Total All Companies	34675	16262	47.8	NA	NA

1. Companies contacted by the Joint Federal-Provincial Inquiry Commission into Safety in Mines and Mining Plants in Ontario.
2. Company submitted lost-time accidents rather than compensable accidents.
3. Injury rate per million hours worked for 1975 to October 31, 1980.
4. James M. Ham, *Report of the Royal Commission on the Health and Safety of Workers in Mines, 1976*, Table D.7.
5. Includes McCreedy West for 1975, 1976
6. Rates includes McCreedy West for 1970 to 1974

The Canadian Centre for Occupational Health and Safety

A review of the literature on attitudes and roles and their effects on safety in the workplace

November 1980

The Canadian Centre for Occupational Health and Safety is a self governing body created by the Parliament of Canada to promote the fundamental right of Canadians to a healthy and safe working environment. The Centre is governed by a Council which includes representatives of business, labour and provincial and federal governments. The council has directed the Centre to begin its work by providing a source of information and advice. This service is at present provided by a group of professionals but in the future the Centre will make increasing use of computer technology to provide information automatically and directly to users.

Introduction

The Joint Federal-Provincial Inquiry Commission into Safety in Mines and Mining Plants in Ontario requested that the Canadian Centre for Occupational Health and Safety prepare background papers for the Commission on the relationship between attitudes and safety in the workplace and role clarity and its effect upon safety.

This was to be performed through a critical review of the literature concerned with how attitudes are shaped in the workplace and the effect that attitudes have on safety in the workplace, together with a review on the effects of role confusion on safety in the workplace.

The breadth of the subject areas and the limited time available for the study necessitated that the reviews could not be comprehensive, however every effort was made to ensure that all major areas of concern were included.

In requesting this information, it is evident that there is some opinion that attitude can play some part in accident causation and prevention. It will be useful therefore, as an introduction to this report, to review theories on accident causation to place points raised in the report in their proper perspective.

According to Hale and Hale, ''the first researchers who looked at accidents in a scientific way were concerned with fitting mathematical models to the observed distributions of accidents'' (*Hale and Hale*, 1972). Probably the most notorious research on distributions of accidents was carried out by Greenwood and Woods (*Greenwood and Woods*, 1919). Their study encompassed all the basic mathematical models to which accident distributions have been compared ever since. These models rest on different types of hypotheses regarding accident liability. These hypotheses are:

1. *that all people exposed to an identical risk are equally likely to sustain an accident from that risk; in other words, accidents are chance events; this is known as the 'pure chance' theory.*

2. *that all people exposed to a given risk are all equally likely to sustain an accident, but that a first accident experience either increases (through some contagious phenomenon) or decreases (through increased awareness) the likelihood of sustaining another accident; this is known as the 'biased liability' theory.*

3. *that all people exposed to a certain risk are* not *equally likely to sustain a first accident from the risk; this is known as the 'unequal initial liability' theory which also became known as the 'accident proneness' theory.*

On the basis of accident data collected in various factories, Greenwood and Woods rejected the 'pure chance' theory (*Greenwood and Woods*, 1919). The correlations they calculated between the accident data and the other two models, led them to conclude that the 'unequal initial liability' model was closer to the observed accident distributions. Newbold arrived at the same conclusion. (*Newbold*, 1926)

Despite numerous methodological cautions both by Greenwood and Woods, and by Newbold, other researchers readily accepted the 'accident proneness' theory. Surry mentions that "the majority of accident research in the 1930s centred around proving the existence of accident proneness". She also points out that 'proneness' is no more useful a concept than that of 'fate'–no one stable personality characteristic associated with proneness has been found during the last fifty years of research". (*Surry*, 1969)

Harsh criticisms have been directed at the 'accident proneness' theory on several grounds:

1. *'Pure chance' cannot be rejected completely since a good fit was found when comparing the distribution of injuries from horse kicks "with a theoretical distribution calculated on the assumption that the kicks were chance events" (*Hale and Hale, *1972).*

2. *Warnings about methodological constraints as issued by Newbold and Greenwood and Woods were generally overlooked by subsequent researchers, leading to undue generalization of the limited, specific or tentative conclusions formulated by these earlier researchers (*Arbous and Kerrich, *1951).*

3. *Much of the research which attempted to support the 'accident proneness' theory was carried out without sufficient care in the selection of samples, and not enough care was taken in ensuring that all members of the samples were exposed to equal risks (*Arbous and Kerrich, *1951;* Froggatt and Smiley, *1964;* Surry, *1969).*

4. *Whereas some statistical models were derived from the theories in order to be compared with accident distributions, the same statistical models could also be derived from other hypotheses or theories, and thus Greenwood and Wood's and Newbold's results do not substantiate only the 'accident proneness' hypothesis (*Fitzpatrick, 1958; Hale and Hale, 1972).

5. *Since there is no clear definition of 'accident proneness', many different interpretations of the concept have been proposed, which has led to a great deal of confusion (*Hale and Hale, *1972).*

6. *One such interpretation was that proneness was a stable trait; attempts to provide evidence for this interpretation included correlations between the accident rates of a sample of people over two different periods of time, correlations between different types of accidents among accident repeaters, and comparisons of accidents during the first period; none of these attempts yielded significant results (*Arbous and Kerrich, *1951;* Kerr, *1957;* Froggatt and Smiley, *1964;* Hale and Hale, *1972;* Smillie and Ayoub, *1976).*

7. *Since it is not possible to differentiate between personal liability and situational liability in fitting statistical distributions to accident data (*Arbous and Kerrich, *1951), Surry rates the applicability of the results of such an approach as 'fair' and their usefulness in providing suggestions for prevention as 'poor'.*

Despite these serious criticisms, the 'accident proneness' hypothesis was readily accepted by many researchers and practitioners. One of the effects of this widespread acceptance was a heavy emphasis being placed on the search for a human cause to accidents. This emphasis was further enhanced by the work of Heinrich, probably one of the most quoted authors on the subject (*Heinrich*, 1931). His theory known as the 'domino' theory is summarized by Hale and Hale as follows:

> *"It postulates five stages: (a) ancestry and social environment, leading to (b) fault of a person, constituting the proximate reason for (c) an unsafe act and/or mechanical hazard, which results in (d) the accident, defined as being struck by, following being burnt by, etc. which leads to (e) the injury. The theory says that these five stages can be regarded as five dominoes standing on edge in a line next to each other, so that when the first falls, it automatically knocks down all the others. Removal of any one of the first four will prevent the fifth, the injury. The classification of accidents by unsafe acts and unsafe conditions used widely in industry is based on this theory."*

Heinrich proceeded to review accident data from insurance companies' records. His analysis led him to conclude that approximately 88% of accidents were due to unsafe acts attributable to 'human factors'.

One of the main criticisms of Heinrich's study is that its data were obtained from insurance company records. These records were essentially investigations performed in order to apportion blame. Surry has this to say about apportionment of blame:

> "*When accident statistics are studied to allot the 'blame' on something, four basic groupings can be made:*
>
> 1. *Victim*
> 2. *Injury agent (the item causing the final injury)*
> 3. *Other environmental factors*
> 4. *Acts of God*
>
> *Typically such groupings indicate '60-80% of accidents are due to human factors'; (i.e. due to the victim). This is a conclusion by default. Since in this scientifically oriented society it is becoming increasingly less fashionable to attribute events to 'acts of God' and, after obvious abnormalities in the environment and injury agent have been accounted for, the remainder of the blame for the accident will fall on that relatively incomprehensible being, man. It is not surprising that 'human factors' play a large part since a human is involved in every accident that we consider. This is in fact, the only common denominator that is involved in all accidents (except possibly time and space). Just the very presence of a man under a falling tool is a 'human factor'–if the human had not been there, no injury would have ensued. It is thus recognized that, used in this manner, 'human factors' is a catch-all phrase which is not very descriptive.*"

As pointed out earlier, however, Heinrich's work gave tremendous impetus to the search for a human cause to accidents. In addition to research on accident proneness, this search explored many other avenues.

Most psychological theories acknowledge that a person's actions are motivated in one way or another consciously or unconsciously, and that no behaviour is totally devoid of some underlying psychological mechanism. When viewing accidents as originating from unsafe acts, and unsafe acts as motivated behaviour, researchers attempted to identify motivations which could be related to accidents.

The first type of research concerned with motivation has been labelled 'clinical studies' (*Surry*, 1969). These studies were mostly influenced by psychoanalytical theories, and all of them postulate that people who suffer accidents do so because of pathological tendencies. Terms such as 'self

punitive', 'suppressed aggression', and 'emotional instability' have been used to describe behaviour leading to accidents (*Surry* 1969; *Hale and Hale*, 1972).

As was the case for accident proneness research, these studies have been harshly criticized. The clinical approach was judged to be incapable of providing reliable methods of prevention for an 'average' population (*Surry*, 1969, *Hale and Hale* 1972):

Another important criticism of these studies is that what 'pathological tendencies' are found in accident repeaters are never defined quantitatively. Furthermore these tendencies are never looked for in so called accident-free subjects (*Surry*, 1969; *Hale and Hale*, 1972).

On the basis that accidents may be a convenient way of staying away from work, Hill and Trist have proposed the 'withdrawal' hypothesis (*Hill and Trist*, 1953). According to this hypothesis, people who are unhappy at work tend to stay away from it for a variety of reasons. As a test of their hypothesis they calculated correlations between accidents sustained by people and their absences from work for other reasons; they found the correlations to be significant. This evidence, however, is insufficient to support the hypothesis. The researchers did not control for important and directly relevant variables such as health status, job satisfaction or risk involved in respondents' jobs.

Kerr put forward two other hypotheses (*Kerr*, 1957). The first one, labelled 'goals freedom alertness' theory, postulates "that great freedom to set reasonably attainable goals is accompanied typically by high quality work performance. This theory regards an accident merely as a low-quality work behaviour". The second, complementary hypothesis is known as the 'adjustment stress' theory. It postulates "that unusual, negative, distracting stress upon the organism increases its liability to accident or to other low quality behaviour". The stresses referred to "can be physical or psychological" (*Hale and Hale*, 1972).

These two theories were formulated to account for a variety of research results not easily encompassed in other theories. These theories have not had much impact so far. The main criticism which can be directed at the research results is that in none of the studies was an effort made to ensure that samples being compared were also comparable on degree of exposure to risk.

The same criticism applies to the vast majority of studies attempting to demonstrate the influence of some personal characteristic or some type of behaviour on accidents.

Other research approaches were developed quite some time after the original 'accident proneness' research. To a certain extent, these approaches were developed out of interest for the other 'dominoes' in Heinrich's theory. These approaches are reflections of important present-day trends in safety.

Epidemiological studies of accidents are particularly suited for the analysis of complex sets of variables and have shed some light on three important notions:

1. *Host factors: "The host is the person to whom the accident happens, the victim" (*Hale and Hale, *1972); typical host factors studied include age, sex, and job experience.*

2. *Agent: "this is the object that directly gave rise to the accident and can be considered as either the types of abnormal energy exchanges that produced the injury or by the specific types of damage produced" (*Smillie and Ayoub, *1976).*

3. *Environment: the term "refers to all the circumstances surrounding the accident" (*Hale and Hale, *1972); the types of environments considered fall into three categories: physical, biological, and socio-economical.*

Epidemiological studies were instrumental in promoting the concept that accidents are complex phenomena involving numerous variables other than 'human factors' and which constituted promising avenues of research.

The second approach is concerned with the situational factors emphasized by epidemiological studies. Although not organized into a coherent structure, the 'situational theories' are concerned with "the accident liability of situations rather than people" (*Hale and Hale*, 1972). For instance, Faverge proposed the theory that unreliability and accidents are syndromes which reflect a breakdown or degradation of the normal working situations; accidents occur at specific junctures of the situation where activities deviate from the normal, usual flow of events (*Faverge*, 1970). Winsemius produced a detailed theory of task structures in which he considers an accident to be a disturbance in the task activity leading to some concrete result (*Winsemius*, 1969).

These theories and this approach are fairly recent compared to other approaches. Therefore, evidence in support of or against these recent theories is scarce, and it is too early to assess it in proper perspective.

Beliefs on causation and intervention methods

The purpose of this section is to draw a parallel between some of the approaches and beliefs discussed above and some of the methods of intervention in the field of safety. More specifically, parallels will be drawn between beliefs on causation and two areas:

1. legislation
2. accident analysis and investigation.

In his review article, Hebert points out that in the nineteenth century prevention of accidents was virtually unknown; the workers were seen as primarily responsible for looking after themselves; civil and common law provided the guidelines by which cases were settled (*Hebert*, 1976). After 1900, prevention was seen in terms of repairing damages, individual employers were seen as responsible, in conjunction with workers, to prevent accidents; the onus of proof was moved from the worker to the employer. After 1930, compensation became formalized; the various industrial accidents Acts required employers, organized according to industry type, to finance a mutual insurance system. Since 1960, Hebert argues, rehabilitation and prevention have become primary concerns along with compensation, responsibilities have been defined for trade unions, and the U.S., as well as for employers and the state and specific laws, have been adopted along with their rules and regulations.

This simplified summary describes broad outlines which can be contrasted with the development of industrial accident research. For instance, it was only at the turn of the century that research into accidents was undertaken, at the time when accidents became a legal concern. Perhaps it is not surprising that research approaches of the time, reflected the general belief of that era; that the worker should be the centre of attention. In parallel with the reversal of the onus of proof and the adoption of industrial accidents Acts, research approaches were developed which were concerned with factors other than human factors (e.g. ‘domino theory’). The recent belief that all parties have a role to play in prevention, and the acknowledgement of this belief in statutory texts, is paralleled by research approaches which stress the multi-factoriality of the accident phenomenon.

A similar parallel can be drawn between research approaches and accident analysis and investigation techniques. For instance, Henrich describes causal factors, the presence of which should be looked for when an accident is investigated. Most of these causal factors were related to behaviour and possible 'unsafe acts'. More recently, along with multi-factorial approaches and emphasis on ergonomics, accident analysis methods (*INRS*, 1974) and accident investigation techniques (*Bonchu*, 1975) have developed into complex systems to encompass an increasingly large number of variables which must be looked into.

It is not sure whether legislation influenced research approaches or whether research approaches influenced legislation. More probably both fields had interactive effects on each other. It may also be that both legislation and research approaches are in fact only two different ways in which generally held beliefs are reflected. This topic is practically not documented in the literature, neither is the parallel between research approaches and accident analysis and investigation methods. One can only notice temporal coincidence between these areas.

Throughout the rest of this report, the word 'accident' is used in its commonly accepted form. No attempt is made to give a specific meaning to it. Many attempts have been made to rigorously define what is meant by 'accident' and all have limitations.

Section I. The shaping of attitudes in the workplace

This section of the report is devoted to a very broad topic. In discussing the shaping of attitudes in the workplace, a large number of concepts need to be touched upon, and a great deal of clarification is needed in order to provide an understanding of the mechanisms which will be outlined. Therefore, the first elements of this section concentrate upon definitions of concepts.

A. Definition of an attitude

Numerous definitions of an attitude have been formulated throughout the years. As Reich and Adcock point out, ''almost every author coins his own'' definition of attitudes (*Reich and Adcock*, 1976). The various definitions, however, contain the essential elements which are commonly accepted as describing attitudes.

Firstly, attitudes are described as 'states of readiness', 'dispositions', 'predispositions'. As such they are psychological baits or structures rather than active behaviour.

Secondly, as summarized by Reich and Adcock, ''each attitude has an affective, cognitive and conative component''. The cognitive component is a readiness to assess or evaluate an object in a certain way; it is the intellectual part of an attitude and encompasses the thoughts of an individual. The affective component is a predisposition to experience emotions related to the object. The cognitive component is also known as the behavioural component; it is the disposition to take action in a certain way in relation to the object.

Thirdly, as Allport points out, ''an attitude is always directed toward some object'' (*Allport*, 1954). In other words, attitudes only exist as a function of some object which is cognitively assessed, which elicits emotions and feelings, and which may generate behaviour. The topic of objects is discussed in detail later in this section.

Fourthly, attitudes have a polarity and a strength. In other words, attitudes can be either positive or negative, with varying degrees of intensity.

Faris suggested certain distinctions. Attitudes are either latent or kinetic; this distinction implies that attitudes are permanent, (although not necessarily unchangeable) traits, but that attitudes operate only when a person is confronted (physically or mentally) with the object of the attitude. Another

distinction is of great relevance to the topic of this section. It postulates that there are individual, as well as group attitudes. This distinction is looked into in a later part of this discussion.

B. Objects of attitudes

Objects of attitudes can be any of a great variety of things: physical objects, people or classes of people, activities, abstract concepts, etc.

In order to reduce the scope of this discussion somewhat, we will focus only upon those attitudes whose objects are directly related to the work situation. Even so, however, the topic remains very complex. The literature on work-related attitudes encompasses a great variety of different topics (*Malinovsky and Barry*, 1965; *Wright and Hamilton*, 1979; *Wall, Cook and Hall*, 1979). The topic of job satisfaction alone has been the subject of much discussion (*Weissenberg and Gruenfeld*, 1968; *Gechman and Wiener*, 1975; *Lawler and Hall*, 1970; *Voydanoff*, 1978; *Hulin*, 1969).

Some of the objects about such attitudes have been discussed at least once systematically or in passing, in scientific journals or in newspapers, include: safety in general, safety laws, rules and regulations, accidents, injuries and/or damage, hazards, causation, work environment, job characteristics, the concept of personal protection and/or specific protectors, company policies, etc.

Given such a broad range of attitude objects, the rest of this section must of necessity, remain general in nature. Specific examples, however, will be used to illustrate precise points or arguments.

C. Whose attitudes?

Safety is a complex area involving numerous individual people and organizations. The literature on safety refers to individuals such as workers, first line management, middle management, top management, and governmental representatives such as legislators and inspectors. Various of these categories of individuals are also structured in specific organizations, such as trade unions, employers' associations, and governmental bodies. Some other organizations further involve representatives from more than one category of individuals or organization. Such mixed organizations include safety committees and health and safety commissions.

It seems plausible that all individuals involved in safety at all levels have attitudes towards at least a few of the objects listed earlier. As groups,

whether formal or informal develop collective stands on certain topics, in effect they develop collective attitudes toward the related objects, even if these attitudes are not of great intensity.

On that basis, one would expect a great variety of individual and collective attitudes to be discussed in the literature. In effect many articles were found to discuss workers' attitudes. Far fewer articles, mostly newspaper articles, were found to discuss management's, specialists' and trade unions' attitudes. Many texts were found to describe official viewpoints on safety matters, but only one article examined some of the attitudes underlying certain statutory texts (*Hale and Perusse*, 1977). Therefore the rest of the discussion in this section will mostly refer to workers' attitudes. It should be remembered, however, that the concepts discussed hereafter are also applicable to attitudes of other people involved in the field of safety.

D. The functioning of attitudes

Attitudes are integrated systems, i.e. the various components of attitudes are so arranged as to function coherently and to organize a coordinated response from a person to an object.

When an object is experienced by a person (when information about it is obtained, when the object is encountered, etc.), the experience is assessed and analysed against the relevant attitudes, i.e., against the integrated systems elaborated from previous experiences. The new experience is interpreted and decoded accordingly. If it is in line with (or seen to be in line with) previous experiences, it is incorporated into the system which is then strengthened.

If, however, the experience is not in line with previous experiences, two situations can occur. If the discrepancy between the new experience and the attitude is small, the experience is likely to be explained away. If the discrepancy is wide, part of the attitude may be thrown off balance, with the result that the attitude is readjusted; the usual learning mechanisms (such as discrimination, generalization, etc.) come into play in order to facilitate the readjustment.

In turn, attitudes serve as guidelines to behaviour. As pointed out earlier, attitudes are only predispositions. In effect, behaviour will be guided by attitudes, but also by a host of other factors such as motivational factors and prevailing conditions. Examples of prevailing conditions which may influence safety behaviour include tradition in the industry, policies, rules

and regulations, work practices, or methods, incentives, production pressures, etc. The resulting behaviour may, because of such factors and conditions, be in contradiction with the corresponding attitudes. But whether or not the resulting behaviour is in line with the attitude, the behaviour constitutes additional experience which is then incorporated into the existing attitudes in the ways described above. Attitude formation and change are discussed in detail later in this section.

E. The manifestations of attitudes

Since attitudes are psychological traits, their identification is very dependent upon the external manifestations of the attitudes. These manifestations can take many forms. For instance, tears may be manifestations of emotional attitudes. Such manifestations, however, are difficult to measure since they are very subjective and almost impossible to quantify.

A great deal of attention has been devoted to the measurement of verbal manifestations of attitudes (*McCormick and Tiffin*, 1974). Research in this area has traditionally used questionnaires usually referred to as attitude questionnaires or opinion questionnaires.

Some clarification of concepts is needed at this stage. Fishbein argues that, whereas attitudes are related to objects or categories of objects, beliefs are related to specific aspects of the object or to individual items within the object category (*Fishbein*, 1967). He further argues that an attitude is the summation of the relevant beliefs. According to McCormick and Tiffin, in Fishbein's theory the sum of beliefs corresponds to the cognitive component of the attitude as discussed earlier. They also mention that opinions are the verbal expressions of beliefs, and thus of certain aspects of attitudes.

Quite a few questionnaire methods have been proposed which purport to measure attitudes. McCormick and Tiffin, in reviewing the main ones, point out that all methods have shortcomings and limitations, whether conceptual or technical.

Therefore, attempts have been made to identify attitudes from other manifestations. On the basis that attitudes influence behaviour, research was carried out which attempted to identify attitudes from their resulting behaviours. Such research has always met with a major methodological hurdle. In order for systematic behaviour observation to be possible, the researcher

must have strict control of all relevant variables other than the attitudes and behaviours under study. Such strict control is only possible in laboratory experiments; therefore, this approach is almost useless in real-life situations.

This topic raises a very important question: is there a link between attitudes and behaviour? Blum and Naylor answer: ''attitudes do not always predict behaviour . . . The favourable attitude toward a certain brand of a television set may not result in that purchase because of price, availability, and the attitude of the salesman. The original attitude may have been measured quite accurately, but it may change as a result of circumstances at the time of the behavioural decision'' (*Blum and Naylor*, 1968).

Research into attitudes towards personal protective equipment provides further examples of discrepancies between attitudes and behaviour. In a study of steelworkers, Iacono found the workers to have very favourable attitudes towards safety gloves, hats and goggles. And yet these protectors were not worn because some workers found them uncomfortable and a nuisance to their work; other workers did not wear them as a means of defying their bosses since the employer-employee climate was inadequate (*Ianoco*, 1967).

In the field of safety, the study of attitudes has rested on a number of assumptions many of which have usually been overlooked. The first such assumption is that accident records provide reliable data. Shipp and Sutton raise serious doubt on that point (*Shipp and Sutton*, 1972). Secondly, it is assumed that there is a link between behaviour and accidents. As pointed out in the introduction of this report, research concerned with the 'human factors' has not been able to produce irrefutable evidence in support of its basic theories. Furthermore, although they attempted to modify what they defined as 'unsafe practices', Komaki et al point out that ''when employees did perform unsafely, they rarely (relative to the number of unsafe acts) experienced an injury'' (*Komaki, Barwick, and Scott*, 1978). Thirdly, it is assumed that attitudes can be measured adequately. It was mentioned earlier that most attitude measurement methods have shortcomings. Fourthly, it is assumed that attitudes influence behaviour. This assumption was challenged in the previous two paragraphs.

For each of these assumptions to be true, several methodological conditions must be met. Considering that there are at least four assumptions each with its own set of conditions, it is hardly surprising that studies comparing measured attitudes with accident rate have generally produced low, non-significant correlations.

This does not necessarily mean that there is no relation between attitudes and behaviour. Blum and Naylor write: "If attitudes are subject to change, when can attitudes predict behaviour? They are likely to do so when all the variables related to the behaviour are known and when new variables are not introduced." (*Blum and Naylor*, 1968).

Considering that attitudes, job behaviour and accident circumstances are all very complex variables difficult to observe and very situational, attempting to fit a specific measured attitude to a certain set of accident data constitutes a non-replicable feat achieved by trial-and-error. Studies which compare the nature of certain dangers with accident rates are much more successful and replicable (*Surry*, 1969).

F. Attitude formation

Very little is known about the way in which attitudes are formed. According to Smith, "theorizing about the modes and processes by which attitudes are acquired should rest upon an extensive 'natural history' of the development of attitudes, based on longitudinal and cross-sectional research that would sample a variety of content domains. The research needed for such a natural history largely remains to be done" (*Smith*, 1968).

A certain number of features of attitude formation have been discussed. Sherif and Sherif mention that it is generally acknowledged "that attitudes are acquired or learned" (*Sherif and Sherif*, 1967). This point of view is shared by McCormick and Tiffin who add that attitude development or modification "is essentially a relearning process" (*McCormick and Tiffin*, 1974).

Since attitudes are acquired or learned, Smith points out that they must have an 'informational basis'. He also mentions that previous authors have proposed "six different ways of acquiring the information . . . blind trial and error, general perception, perception of others' responses, perceptions of the outcomes of others' explorations, verbal instructions relevant to behaviour, and verbal instructions about objects' characteristics" (*Smith*, 1968). It is not sure, however, whether these six modes play an equal role in attitude formation.

Other authors have insisted on the importance of the source of information on attitude formation. For instance it was pointed out earlier that one of the four conditions proposed by Allport for attitude formation was "the adoption of attitudes by imitation of parents, teachers, or peers". Blum and Naylor support this view. They add that people tend to adopt the attitudes

of groups to which they belong or of people to whom they want to be associated. On this basis, it seems likely that co-workers are influential in the development of attitudes. However very little evidence is available on the subject.

Finally, Blum and Naylor point out another source of information which influences attitude formation. They argue that mass communication media play a major role in the shaping of audience attitudes. Examples of this are described by Glendon in relation to accidents (*Glendon*, 1975). He argues that it is those accidents which make the headlines which spur public opinion into action. Air crashes make the headlines because they kill many people at once. Occupational accidents seldom make the headlines since they kill fewer people at once; and yet many more people die of occupational accidents each year than of airplane accidents.

G. Attitude change

If the topic of attitude formation is little documented, in contrast, attitude change has been the subject of much research. The number of theories is impressive, and only the main ones are reviewed briefly hereafter.

Various 'learning theories' have formed the basis of experiments in which verbal and/or behavioural manifestations of attitudes in the desired direction were reinforced. Such reinforcements were shown to modify attitudes, e.g. the wearing of protective equipment may create a positive attitude towards the usefulness of the equipment.

The proponents of 'cognitive approaches' have argued that objects attributed to prestigious sources (for example, famous persons) are more likely to cause a readjustment of attitudes than objects attributed to unattractive sources. This attribution process, it is argued, serves "to provide a new context of meaning that induces changes in the cognitive object, about which changed evaluative judgements and accompanying effect are then appropriate" (*Smith*, 1968).

Theories dealing with 'judgemental processes' postulate that any information or communication about an attitude object is assessed on a pro-con scale in relation with one's own position on the subject. The theory also postulates a margin of latitude on both sides of a person's own position; when new information falls within this margin it is likely to have an effect on the attitude; otherwise, the new information is rejected and the discrepancy between new information and attitude is exaggerated in order to rationalize

the rejection. Another postulate of this theory is very important and is referred to in another section of this report. This postulate is summarized by Smith as follows: ''the same objective differences in the positions of two communications may be perceived very differently by different individuals, depending on the nature of their judgement scales, which in turn are determined by such factors as their familiarity with the issue and the extremity of their own positions''. It is argued that the greater a person's ego-involvement in an issue, the narrower the margin of acceptance is. An example of this process would be the rejection of protective equipment, if it was perceived as an approach by management to avoid control at source.

Various theories (i.e. the Congruity theory, the Dissonance theory and the Balance theory) are collectively referred to as the 'equilibrium theories'. These theories postulate that disequilibrium in a person's attitudinal system is conducive to attitude change. The theories are in fact concerned with different types of disequilibrium.

The 'cognitive consonance/dissonance theory' postulates that consonance exists when all the components (cognitive, affective and conative) of an attitude are in line with each other. Dissonance arises when one of the components is not in line with the other two and when the person is aware of the disequilibrium; dissonance is conducive to change since people seek to eliminate the disequilibrium, e.g. a person who firmly believes that accidents are as a result of carelessness, meets with an accident himself.

The congruity and balance theories postulate that when attitudes towards related objects are not in line with each other, readjustments take place in order to remove the disequilibrium in the attitudinal system.

Consistency theories further postulate that when many attitudes are involved, change will occur in that direction which requires the minimal number of readjustments.

These theories introduce two important concepts: that of valence and that of linkage. Valence is either positive or negative. People expect all the attitudinal objects which they value (positive valence) to cluster together, and all objects which are regarded as rejectable (negative valence) to be linked together. In his review of these theories, Brown argues that there are basically two types of disequilibrium (*Brown*, 1977). The first type involves two objects or items of opposite valence (one negative and one positive) which are associated (positive link; e.g. a highly valued person

expressing an unacceptable opinion). The second type involved two objects of similar valence (both positive or negative) between which there is a negative link (e.g. a highly valued person rejecting one's point of view). The basic change strategies involve either modifying the link or changing the valence of one of the objects.

Various approaches have been developed from certain theories of personality, notably from psychoanalytic and self theories. Such approaches, however, entail that ''rigor and precision are likely to be sacrified in favour of relevance to human experience and problems''. These approaches are concerned mainly with the role of attitudes in the personality structure, and as such they have only indirect implications for attitude change (*Smith*, 1968).

Smith reviews various ''functional approaches to attitude change'' which are ''not tied to any single theory of personality''. These approaches are concerned with the study ''of the functions that a person's opinions and attitudes serve in the ongoing economy of personality, on the assumption that knowledge of the motivational basis of attitudes should point to the conditions under which change can be expected''. These functions are summarized in three categories: ''object appraisal, social adjustment, and externalization''.

Attitudes as object appraisal systems serve to simplify a person's task of assessing new information about objects ''by providing him with already evaluated categories to which incoming information can be fitted. The object appraisal predominates, attitudes should be malleable, in response to rational presentations of information that lead the person to reappraise the bearing of reality factors on his interests and enterprises''.

Attitudes also service the function of facilitating (if association or conformity is sought) or disrupting (if non-conformity or dissociation is sought) a person's ''relations with significant others''. ''Here the strategic information pertains to how other people regard the object. This information engages his motives to affiliate and identify himself with them or to detach himself and oppose them. The influence of reference groups on a person's attitudes is classified here''.

Finally, it is argued that attitudes serve to express drives and tendencies which emerge from ''a person's unresolved inner problems'' which could not be expressed otherwise. ''Attitudes so motivated are unlikely to be influenced by rationally presented information, but they may respond to

authoritative reassurances that allay anxiety, to changes brought about in self-insight, or to the uncovering processes that go on in psychoanalytic therapy''. Other classifications of attitude functions bear great resemblance to the one discussed above (*Smith*, 1968).

H. Conditions of change

Blum and Naylor review previous research on attitude change and mention certain conditions which influence change. Change, it is argued, ''is a function of seven attitude characteristics: (1) extremeness, (2) multiplexity, (3) consistency, (4) inter-connectedness, (5) consonance, (6) strength and number of wants served by the attitude, and (7) centrality of value to which the attitude is related''.

These characteristics can be divided into characteristics of the attitude and characteristics of its relations with other aspects of a person's traits and beliefs:

1. *attitudes characteristics: extreme attitudes are less likely to be modified than mild attitudes. The more complex an attitude, the less likely it is to change direction, but the more likely it is that its intensity will increase in the present direction. Attitudes, all components of which are in line with one another, are less likely to change.*

2. *characteristics of the relations between an attitude and other traits: attitudes which are connected to other attitudes will not readily be changed. For instance, if attitudes towards injuries is part of a well-integrated system, which also includes attitudes towards hazards, towards risk, and towards safety responsibilities, such attitudes are not likely to change individually. Change is even less likely to occur if these various attitudes are in tune with one another. ''Since attitudes can serve many wants and needs of an individual, the possibility of change will depend upon the number and strength of the wants served. And, last, the closer the attitude is to a basic value held by an individual, the less likely is change to occur'' (*Blum and Naylor, *1968).*

I. Factors affecting changes

Given that certain conditions are conducive to change, certain factors must intervene to make the change happen. The following paragraphs include a categorization of certain factors which were found in the literature and

which have been argued to be (sometimes without supportive evidence) attitude change precipitators.

1. Information

*It has been pointed out earlier that providing new information to a person can have an effect on the cognitive component of an attitude, and thus possibly on the whole of the attitude. Much has been written about the effect of information communication on attitude change (*Sherif and Sherif, *1967;* Reich and Adcock, *1976;* McCormick and Tiffin, *1974;* Hovland, Janis and Kelley, *1953). Hereafter is only a short summary of a very largely documented field.*

Hovland et al *argue that the factors which influence attitude change are related "to the nature of: 1) the communicator (who says it), 2) the communication (what is said), and 3) the audience (to whom it is said)". Communicator factors include such variables as credibility, attractiveness and expertise. Sources of information (communicators) in the workplace include: organizational formal sources such as company policies and training, organizational informal sources such as peers and groups, extra-organizational formal sources such as statutory texts, research findings and other official information providers, and extra-organizational informal sources such as mass media and one's friends, relatives and reference groups.*

Communication factors which influence attitude change include salience of group norms, explicit or implicit conclusion drawing, preparation for future experiences, primacy or recency effects, attractiveness and repetition of message, etc.

Audience factors include variables such as personality traits (e.g. susceptibility to persuasion), strength of pre-existing attitudes, selective intake (filter), and interpretation of message in relation to one's own stand.

A fourth category of factors, related to the way in which a communication is presented, has been added. Such a category includes variables such as mode of transmission (oral or written, etc.), distraction or distortion, and fear arousal.

A detailed discussion of these numerous variables and their effect on attitudes would, of necessity, be long and tedious. Those variables which have been studied in relation to safety are described in the next segment of this section.

2. Experience

It was argued earlier that a person's experiences form the backbone of his attitudes. The process by which new experiences contribute towards modifying attitudes has also been touched upon. Various types of experience contribute towards shaping or reshaping safety-related attitudes. Job experience (general experience or accidents suffered), overall work experience (general or accident-related) and everyday experience (e.g. accidents suffered away from work) are all susceptible to be incorporated into attitudes.

3. Motivational factors

As pointed out earlier, behaviour can be affected by attitudes, but also by other motivational factors. In turn, attitudes which are closely related to a person's wants and needs are the more stable ones.

A review of the various theories of motivation is not called for here. However, certain considerations must be raised.

Motivational factors are often divided into intrinsic and extrinsic factors. Intrinsic factors are those which are related to one's personality, beliefs and needs. Intrinsic motivational factors which have been discussed in relation to safety include the value of one's life, perceived advantages of various courses of action, need achievement, job involvement, job commitment, job satisfaction, etc.

*Extrinsic factors are those which are related to attempts by others to influence a person's behaviour. It is generally recognized that extrinsic factors are far less effective in shaping behaviour than intrinsic factors (*Hogue, *1975). Extrinsic factors which have been discussed in relation to safety include production pressure, leadership, working conditions, incentives and programs, promotion prospects, etc.*

J. The changing of safety-related attitudes

Various studies have discussed ways of changing attitudes towards objects related to safety. The main ones are discussed hereafter.

1. Motivation

*Aldridge reviews some of the theories of motivation in an attempt to explain why accidents happen (*Aldridge, *1976). Other authors have also discussed motivation in relation to accidents and safety (*Sparz, *1978;* Hall, *1975;* Betz, *1976). However, none of these articles provides clear indications of how 'safety motivation' can be achieved. None provide supportive evidence. In any case, as pointed out earlier 'motivating people' involves the recourse to extrinsic factors which are less likely than intrinsic factors to influence behaviour.*

Incentive schemes, advocated as ways of motivating workers, have been argued by others as causing under-reporting rather than actually reducing accidents. This is probably why attention has been redirected towards intrinsic factors, and hence back towards attitudes and their components.

2. Information

*One of the ways of reshaping attitudes which has attracted much attention is information providing. For instance, Petersen discusses a research in which workers were asked: "Following are standard communication methods in safety. How good are they in reminding you or motivating you to work safely?" (*Petersen, *1973). The results classify the various methods according to their perceived usefulness. However it is not certain whether the most useful methods as perceived actually have an influence on behaviour. Piranis and Reynolds compared various ways of providing information. Although all methods produced results on a two-week period, only role play produced results noticeable after a four-month period (*Piranis and Reynolds, *1976).*

*A great deal of attention has been devoted to fear-arousing communications. It is now generally agreed, both on general grounds and in relation to safety that such communication has little and sometimes counter-productive effects (*Hovland, Janis and Kelley, *1953;* Hale and Hale, *1972;* Smith, *1968).*

3. Experience

*On the basis that experience modifies attitudes, and that training is one way of enriching a person's experience, studies have been done on job training. "There is broad agreement in the accident literature that accident rate declines as experience on the job increases" and thus providing job training reduces accidents. "The conclusions which can be drawn from the studies are, however, tentative, as most of them fail to give details of the training or the subsequent work of their groups" (*Hale and Hale, *1972).*

*Although many studies have indicated that safety training tends to reduce accidents, they "cover a wide range of situations and results are difficult to interpret unambiguously" (*Hale and Hale, *1972).*

*Accident simulation has also been used, and results indicate a reduction in mishaps (*Rubinsky and Smith, *1973). But little is known about the applicability of the method.*

Other approaches have been concerned with behaviour, on the basis that inducing people to adopt certain behaviours would cause them to readjust their attitudes accordingly. These approaches have included negatively reinforcing undesired behaviours and/or positively reinforcing desired behaviour.

*Disciplinary sanctions can be seen as negative reinforcements of undesired behaviour. In two studies these were shown to have no effect on the wearing of personal protective clothing and sometimes to be counter-productive, e.g. sabotage of protectors (*Cesa-Bianchi, and Di Naro, *1964;* Pirani and Reynolds, *1976).*

Some studies, carried out by NIOSH *among others, were concerned with shaping safe behaviour by positive reinforcements. Generally these studies were successful in shaping safe behaviour. However, one study showed a reduction in accidents in the control group as well as in the experimental group (*Smith, Anger, *and* Uslan, *1978). Many studies also provided training as well as reinforcements; therefore it is not certain whether the effects were due to reinforcements or to training.*

Section II. The effects of attitude on safety in the workplace

A number of attempts have been made to correlate attitudes with safety. In order to do this, criteria of safety effectiveness have to be found, together with some way of measuring them.

A. Measurement of safety performance

Measurement has generally involved the event, (or its consequences), that has been labelled 'accident'. As stated in the introduction, there are many conceptions of the nature of an accident and the conception selected will influence the measurement procedure employed. For example, the belief that accidents are a chance event, or 'Act of God', would lead to no attempt being made to tabulate incidence, since it would serve no purpose. Similarly the conception that accident involves injury will lead to tabulations of numbers of injuries or injury rates.

The most common method used to quantify safety performance is through the frequency with which accidents occur, usually expressed as a ratio between the number of such events and the exposure of personnel to risk. The types of accidents studied have fallen into four categories depending upon their consequences.

1. Fatalities: in which death occurred as a result of injury.
2. Disability: in which permanent disability is produced as a result of injury.
3. Minor injuries: in which injury has been such that the injured person is unable to work for one or more days.
4. Incidents: have included minor accidents resulting in medical aid on site and also 'near misses'.

The use of frequency ratios has limitations. The major injuries are statistically rare events which make conclusions about trends difficult to define. The minor categories suffer from reporting inconsistencies and inaccuracies, which make cross comparisons between different groups of workers very difficult.

A second indicator that has been used is the severity ratio which looks at safety performance in terms of the number of days lost (arbitrary figures usually included for death and disablement) as a fraction of number of hours of employee exposure to risk. The major problem here is that length of time away from work depends upon individual physicians, and there will be differences in the opinions of each as to when a person is fit to return to work. There are also differences in companies' abilities to provide

alternative work which takes account of the injury, allowing early return to work of the injured worker.

Other indicators which have been used include the number of violations of regulations, both legal and corporate, which of course requires that the violations be observed and recorded. As well, cross comparisons require that all groups are subjected to the same frequency and quality of inspection.

Incidence of dangerous behaviour has also been used which has the obvious drawback that it requires a definition of dangerous. What is dangerous for one person is not necessarily dangerous for another, and the recording becomes highly subjective.

Incidence of errors in performing routine tasks is another method which has been given attention and which could have further application in the industrial setting.

B. Attitude measurement

As pointed out in Section I, attitudes are normally measured through verbal manifestations, either by interview or questionnaire.

Studies that have been performed have not always attempted to link attitude to actual safety performances but have simply pointed out the prevailing attitudes and left the reader to determine for himself how these attitudes might affect safety in the workplace.

Typical of this type of study was one carried out on West Virginia miners (*Palomba and Althouse*, 1975) in which miners' attitudes towards health and safety were recorded. The miners included in the study were relatively young, upwardly mobile miners of which half had worked 1 to 4 years in mining. The conclusions of the study were:

1) *The majority of the miners felt it was their own responsibility to make themselves aware of safety rules and laws.*

2) *The miners interviewed believed there was less knowledge of the use of safety equipment than of its location.*

3) *There was apparently less knowledge of emergency routes and procedures than of safety rules.*

4) *About 80% of those interviewed indicated a need for more safety training.*

5) *The miners felt that moving and falling objects were the greatest threat to safety.*

6) *Human factors, e.g., lack of training were viewed as less of a threat than physical factors. Of human factors carelessness was viewed as the greatest threat.*

7) *While foremen and supervisors were rated highly on their knowledge and understanding of mining, they were rated lower on their ability to communicate well with miners and on their knowledge of the work background and experience.*

The empirical links between these conclusions and safety performance were not established, which leaves unanswered the question of how these various factors might influence safety performance.

C. Attitude to risk

A number of studies have attempted to correlate the measured attitudes (or sometimes behaviour) with indicators of safety level and these form the basis of the remainder of this section.

Grimaldi in discussing risk taking suggests that people are generally prepared to take risks (*Grimaldi*, 1970). In making safety decisions four judgement factors are taken into account.

1. The likelihood (probability) of an unwanted consequence occurring
2. The maximum degree of harm that could result from the consequence
3. The social-sensitivity of the issues associated with the possible consequence (i.e. their legality or ethicalness)
4. The magnitude of the gain expected from the action taken.

In reviewing risk-taking, Surry defined danger, hazard and risk. Her definitions and a well thought-out example are presented here:

> *This type of decision has the added variable of personal danger and is common in the accident development stages. It is of interest to compare what people estimate they can do, what they will try to do, and what they can actually do in the face of danger. At this point some definitions of terms should perhaps be made. 'Danger', 'hazard', and 'risk' have varied meanings among both laymen and professionals. This author prefers the following definitions: 'danger' is the presence of a situation which could inflict injury or damage if an error*

is made; the 'degree of hazard' is the objective probability (i.e. the measured probability) that a man will err in the presence of danger; the 'degree' of risk is the subjective probability (i.e. the individual's estimate) that the man will err in the known presence of danger. 'Risk taking' is the willing performance of an action which has been judged to have a nonzero degree of risk.
*An example may illustrate the meaning of these definitions. A man is asked to walk on a narrow bar when it is (a) on the ground, and (b) in the air. In the first situation there is no danger involved and the man is aware of this; hence by definition, there is no hazard or risk. In the second situation there is a danger involved as a result of the height; the degree of risk is the man's estimate of his chances of failing to walk along the bar, and the degree of hazard is measured by the number of times that he actually does fall off. If the man is now blindfolded and is not told at what height the bar is, on the ground the danger and hazard are zero, but the man estimates a positive degree of risk since he does not know his height. In the air the danger is the same as when not blindfolded, the hazard being probably higher since there are no visual aids for performance of the task, and the risk will be estimated to be exactly the same as when on the ground blindfolded. It can be seen that the 'degree of risk' depends on the estimate of both the presence of danger and of the ability to perform the task.'' (*Surry, *1969).*

Hale and Hale have reviewed several of the studies which have relevance to the subject. What they have to say is presented here.

1. *Robaye et al conducted an experiment in which subjects were shown photographs of work situations and were asked to estimate the risks involved in the depicted situation. They also were asked to estimate how often the situation occurred and how frequent were a number of possible outcomes (*Robaye, Hubert and Decroly, *1963). The results of the questionnaire were then correlated with the subject's accident record. They found that subjects with a high accident record judged the risks of the situations to be greater, and considered that they themselves had experienced the situations more often than those with low accident records. The high accident record subjects also underestimated the frequency and severity of injuries which could result from the situation.*

2. *Similar work was carried out by Spaltro (*Spaltro, *1967). He presented every day situations to his subjects in questionnaire form and asked them to estimate the risks involved. He then asked what they thought the general population would think the risks were. Another group*

of subjects were asked to estimate the desirability of the situations. His findings were that the majority of his subjects thought that the general population would underestimate the risks. He also found that the situations judged more risky were also judged less personally desirable and, like Robaye, he found that accident repeaters estimated the risks in the situation to be higher than the accident free group.

3. *Merz used a laboratory sorting task with values attached to correct and incorrect responses and a variable speed of presentation of the objects to be sorted (*Merz, *1967). He studied the strategies used by groups of accident repeaters and accident free workers. The accident repeaters opted for faster speeds of work bringing in their train more errors. They also failed to modify their strategies in the light of results. These findings were in marked contrast to the accident free group.*

4. *Molitor and Mosinger produced a questionnaire asking for subjects' attitudes to a series of items to do with fire, ranging from sparks and candles up to volcanoes and atom bombs, and asked them to rate them on a scale from highly desirable to highly undesirable (*Molitor and Mosinger, *1967). Accident repeaters had low fear scores while accident free workers had either very high or very low ones.*

These four studies did not use actual workplace situations and so the results have to be treated with caution in extrapolating to the industrial situation.

A study of driving tasks by bus drivers, showed that they tended to overestimate the risk in easy tasks and underestimate it in difficult tasks. (*Cohen*, 1956). Training altered risk judgements so that trained drivers would not undertake such risky tasks as the untrained. A later study by the same authors showed that alcohol impaired risk judgement.

It was also reported by Hale and Hale that a European study by Harper and Kalton on coal miners, found that the accident rate was correlated to how dangerous the work was perceived to be. Accident repeaters tended to regard their work as more dangerous than accident free workers (*Harper and Kalton*, undated).

These studies were criticized by Hale and Hale. The main problem they saw with all of these studies is in deciding what is cause and what is effect. Harper and Kalton pointed out that the effect could be the result of

a personality difference, accident repeaters being nervous, or it could be a post hoc rationalization, ie. the workers who had the most accidents regarded their work as more dangerous than it was because they wanted to preserve their self respect and conversely that those who had not had accidents, judged the situation to be less serious than it was because they had no experience of the danger. Hale and Hale added a third possibility; that there were in fact differences between the jobs of the accident free and the so-called accident prone, which made the latter's work actually more dangerous, something which none of these studies had controlled for.

D. Attitude towards the job–job satisfaction

Studies in this area are based on the premise that dissatisfaction causes lack of care and attention and hence the worker adopts unsafe practices, resulting in accidents.

Hale and Hale in their review article comment on several studies in this area. These comments are summarized here.

The effect of excessive work rate and accident frequency have been correlated (*Neuloh, Fraf, Ruhe, and Mausolff*, 1957), but whether this occurs because of the excessive work rate itself or because of dissatisfaction produced by the excessive work rate was not distinguished. Keenan *et al* also studied the effect of excessive work rate, among other factors, on accident frequency and found them not to be correlated (*Keenan, Kerr, and Sherman*, 1951).

Other factors examined by Keenan *et al* were promotion prospects and they found that dissatisfaction due to lack of possibility of promotion to be highly correlated with accident frequency, but differences in exposure to risk were not controlled and these results could have been coincidental.

Davids and Mahoney used two groups of subjects matched for age, education, intelligence and socio-economic background and exposure to high accident hazard. One group had a high accident rate, the other not. They found a significant correlation between the high accident group and a negative attitude towards the job (*Davids and Mahoney*, 1957).

Harper and Kalton also found that there was a correlation between high number of accidents and low morale in coal miners.

The criticism levelled at these studies by Hale and Hale was that it is not possible to distinguish whether the job dissatisaction or low morale is a result of the accidents or vice versa.

They also pointed out that dissatisfaction could cause an increase in the proportion of accidents reported and increase the length of time a person will stay away after a more serious injury.

Production pressure was also linked to an increase in disabling injuries in mines in a study by Sanders *et al* (*Sanders, Patterson, and Peay*, 1976).

Job satisfaction can be the product of a management attitude toward safety or towards the general welfare of the employees. Where management is perceived as caring, then an atmosphere of cooperation results. An example of this was seen in one coal mine, where, in one experimental section of the mine, the management and union established organization of work jointly (*Trist, Susman, and Brown*, 1977). The main points of the agreement arrived at were:

1. *Every worker in the experimental section would be on top pay.*

2. *All crew members would be trained to be capable of performing any job in the section and would be given special training in State and Federal mine safety laws.*

3. *Crew foremen would be primarily responsible for the safety of the crew. Responsibility for production would be transferred to the entire crew now without a boss.*

4. *Grievances would be dealt with by 'peer discipline'.*

Interviews conducted with the men indicated that they believed they were making more of the decisions about the organization and performance of work and they believed their co-workers had good ideas to contribute. They also felt themselves respected by management as never before.

Safety performance as measured by number of safety violations and also by accident frequency was improved when compared with the performance of two other sections operating under more traditional organizational structures.

On the other hand, a study of nine factories in the light metal industry in Helsinki indicated that job environment could be a causal factor in accident production (*Saari and Lehtela*, 1979). Changes in job structure to relieve monotony, had the workers performing a larger variety of tasks and the workers were given more responsibility for planning their own work. Workers

in such situations were found to have a higher accident frequency than workers in areas where the work was more preplanned and where there were a smaller number of tasks to be performed.

Hinze conducted a study of how foremen and management treat new workers to their crews and its relationship to safety (*Hinze*, 1978). The conclusions were that:

1. *The foreman's manner of dealing with new workers had a strong influence on the safety record of the crew, and*

2. *The safer foremen interacted more with new workers asking them many questions, expressing an interest and concern for the new worker.*

3. *The safer foremen watched workers closely during their first few days on the job.*

4. *In communications the safer foremen did not consider safety as being separate from the work to be done.*

Hinze also showed a correlation between top management communication with workers and accident frequency (*Hinze and Punnillo*, 1978).

A study showed that management attitudes towards work and safety important (*Eysson, Hoffmann and Spengler*, 1980). They studied accident rates of workers in union administrative districts within one company. Managers in districts with low injury rates were more likely to believe that their men had a relatively high risk of injury, that safety was more concern to them than other work issues and that they themselves and the tools and practices at their disposal were capable of preventing accidents. They also believed that their ability to carry on safety work was enhanced by incentives rather than hindered by barriers.

A study of eleven matched pairs of similarly sized firms in eleven different industries, but with one firm in each pair having a relatively much lower injury frequency than the other concluded among other things that firms with better safety records have top management highly interested and involved in the companies' safety performance (*Shafai-Sahrai*, 1973).

In a review of recent research on successful occupational safety programs, Cohen found that the two most influential factors were:

1. *a strong management commitment to safety and*

2. *good communications concerning safety factors between all groups in the workplace. (*Cohen, *1979).*

Both of these factors are consequences of the attitude of management towards safety. This review considered research based on questionnaires, analysis of practices in companies with outstanding safety performance, and analysis of practices in similar companies with high versus low injury rates.

The following factors were identified by Cohen as being common features of successful safety programs studied:

1. *Strong management commitment to safety as defined by various actions reflecting management's support and involvement in safety activities.*

2. *Close contact and interaction between workers, supervisors, and management enabling open communications on safety as well as other job-related matters.*

3. *A workforce subject to less turnover, including a large core of married, older workers with significant lengths of service in their jobs.*

4. *A high level of housekeeping, orderly workplace conditions, and effective environmental quality control.*

5. *Well developed selection, job placement, and advancement procedures plus other employee support services.*

6. *Training practices emphasizing early indoctrination and follow-up instruction in job safety procedures.*

7. *Evidence of added features or variations in conventional safety practices serving to enhance their effectiveness.*

Cohen concluded that:

> "*Management commitment to safety was believed a major, controlling influence in attaining success in industrial accident prevention efforts. Open communication between workers, supervisors, and management was also considered of great significance. Overall, the nature of these distinguishing factors suggested that maximally effective safety programs in industry will be dependent on practices that can successfully deal with 'people' variables.*"

As can be seen, most of these factors are directly related to the attitude which management has about safety.

Later Cohen reported on an on-site study of seven matched pairs of high-low accident rate plants, analyzed for differences in occupational safety programs. (*Smith, Cohen, et al,* 1978). The four factors identified by the study as related to superior plant safety performance (as measured by low reported accident rates) were:

1. *Low accident rate plants had greater management commitment and involvement in plant safety matters. In addition, the management of the low accident rate plants displayed greater skills in managing both material and human resources.*

2. *Low accident rate plants used a humanistic approach to dealing with employees in which greater levels of informal worker/supervision interaction were encouraged.*

3. *Low accident rate plants had a higher level of housekeeping and displayed environment qualities superior to those of the high accident rate plants.*

4. *Low accident rate plants had less turnover and absenteeism and a more stable work-force.*

All of these factors are indicators of management attitudes, particularly of commitment and attitudes toward safety.

Hebert in a review of the role of management in accident prevention identified the attitude of the organization (management) towards safety as the single most important set of causes of accidents. That is, the importance or lack of importance of safety as a company priority, determines to a large extent the cause or absence of accidents. (*Hebert*, 1976).

E. Attitude towards safety and productivity

Production has been identified by some authors as being the factor most in conflict with safety. Schlag-Rey et al found that the majority of workers they studied considered that safety acted as a brake upon production (*Schlag-Rey, Ritas and Chaperon du Laret*, 1961). They also considered that safety was less meaningful to workers than productivity because it was a potential rather than reality, a risk not a certainty.

Henrich has argued that safety and productivity should go hand in hand since there are similarities between deficiencies in both areas and their correction. Some of the results from studies quoted in the section on job satisfaction would support this.

A study conducted in Sweden, looked at changes in the pay system and its effect upon safety (*Krolund*, 1976). Five thousand miners in Swedish iron-ore mines went on strike for a change in the pay-system to a fixed monthly rate based on time at work; a change from the old mix of piece rate and bonus systems used. The frequency of major accidents decreased quite dramatically over the following three years. Whether this was a function of a change in attitude of workers as a result of a change in the pay system alone is a matter of debate, since there were other factors involved in the strike and there were several changes in the underground working environment after the strike, for example the introduction of health and safety stewards. A review ten years after has suggested that the strike was a major influence in changes in Swedish legislation in occupational Health and Safety (*Swedish Work Environment Association* 1980); hence the decrease in accident frequencies could also, or additionally, be due to the perception that safety concerns were at least being addressed.

F. Attitude to legislation

One American study was found which examined the attitudes of local union officers toward OSHA and its incentive-based alternative, the imposition of an injury tax (*McLean and Schneck*, 1979). The study found approval of OSHA as a deterrent to industrial accidents. However, the degree of satisfaction was unrelated to the injury frequency rate experienced by the members of the union officers locals.

G. Effect of prevailing conditions

It has been pointed out that the conceptual model that attitude affects behaviour, which in turn is related to accident production is too simple. Other factors can play a part. Behaviour is not only determined by attitude but also upon other conditions pertaining at the time. The result can be a conflict situation where attitude could demand one type of behaviour but a prevailing condition can dictate another course of action.

One major prevailing condition is the cost of introducing changes which lead to improved safety. The importance of this area is borne out by

the large and growing number of publications in the cost-benefit field. It is not our intention to review this literature here but only to point out that it exists.

Legislation too can play a major part. A British accident prevention study of five factories showed that continuing attention to compliance with the law was linked to low accident incidence (*Accident Prevention Advisory Unit*, 1976).

The total work environment too is important. For example, ergonomically well designed workplaces and safe equipment are necessary for good safety attitudes to be translated into safe working practices.

The organization is a major factor in itself both in terms of the way it is set up and the roles the various parties play and this will be the subject of the next section of this report.

It would therefore, be unwise to concentrate only on attitudes in attempting to reduce accidents, and ignoring these other factors. Attitudes can be important and the results would indicate that perhaps examination of management attitudes could be the most fruitful area for further research. As was pointed out by Krolund, the ability to exercise influence over prevailing conditions is hierarchical with management being in a stronger position and therefore able to exercise some control on behaviour from this aspect also (*Krolund*, 1976).

Section III. Role problems in the workplace

The concepts of role and role patterns in human behaviour are extremely complex phenomena. No studies relating to problems concerning role confusion in industrial safety could be found in the literature. The approach adopted in this presentation is to first lay down a conceptual framework as an attempt to pinpoint the major theoretical concerns relating to role problems in organizations and then expand on the practical implications arising from those towards the industrial safety situation.

A. Conceptual framework

In developing the following conceptual framework, the works of several authors were used as background material (*Gross et al*, 1958; *Goffman*, 1959; *Kahn et al*, 1964; *Sarbin et al*, 1954; *Linton*, 1945; *Mead*, 1934; *Hunt*, 1965; *House and Rizzo*, 1970; *Merton* 1957).

The term 'role' may be defined in simple terms as the 'expected behaviour of the occupant of a position within a group'. Within an activity system, such as an industrial organization, it refers to the activities that an individual contributes to that particular system and to interrelations involved in carrying out those activities. Role is related to a position and not an individual. Although there can be differences in the behaviour of different individuals in the same position, the basic role pattern is derived from the position.

The structure of a formal organization consists of a complex of positions which are interlocking, at least partially. These positions could be seen as patterned in terms of complementary expectations (for example, rights and duties) which are related to roles concerning those positions. Role is also not limited to the expectations of any component category of a group, but is a composite of the expectations of all the members of that group.

In order to examine the range of problems which may occur with respect to roles in organizations, it is necessary to examine some related phenomena.

Often, the role of a given position (for example, first line supervisor) would be organizationally related to many counter positions (for example, workers, second line supervisors, specialist professionals, top management, etc.).

The role of a particular position can be fully described only with reference to the roles of its other complementary positions. The total spectrum of such complementary counter positions to a particular position is said to describe its role-set.

When the counter positions to a particular role are considered one at a time, the expectations associated with the relationship between a given position (for example, the safety professional) and a single counter position (for example, the top management) is termed role-sector. Role would vary depending on the specific counter position of a role-sector considered. For example, the role of a safety professional in relation to the top management is different from that in relation to first line supervisor or worker.

Normally, three major sources are involved in determining roles in organizations.

1. Formal functional descriptions which also describe duties, responsibilities, authority, etc. attached to different positions in the organization. Although, through its organization, an enterprise assigns activities to positions, positions to individuals and groups, etc., it cannot always predetermine the consequential role-sets.

2. The individual himself, by his own perceptions, expectations, and interpretations of how he ought to behave. This refers to a synthesis of personalized representations of the requirements within the organization, some of which may be acquired as a consequence of direct experiences and others may develop as a result of indirect influences. These may result in variations between different persons occupying similar positions.

3. Other members of the organization who project their expectations through interpersonal relations. It was mentioned earlier that roles are constructed from behaviour specifications relating to the person himself as well as to the occupants of positions complementary to his own. The term 'role-sender' describes each counter person communicating such expectations and the communicated expectations are called a 'sent-role'. From the perceptions of sent-roles and other influences, a person not only develops specifications concerning his own behaviour and expectations of others' behaviour, but also forms characteristics of what others expect of him.

It can, therefore be seen, that roles in organizations arise from a highly complex mutual influence network.

B. Role problems

In an industrial organization, where a large number of individuals occupy a whole range of different positions, of which many are interrelated in a

variety of different ways, there is much room for confusion resulting from role problems. Two broad categories of organizational stress due to role problems have been differentiated; role conflict, and role ambiguity.

C. Role conflict

Role conflicts in organizations may occur in the following five different ways.

1. When the role constructions of two or more positions which are relevant to a situation and which an individual perceives himself to occupy, are not compatible. For example, conflict may occur as a perceived incompatibility between a person's expectations of his role towards promotion of safety and his role towards improvement of production rates.

2. A person's role expectations pertaining to other role incumbents being incompatible. The conflict here arises from the projected behaviour of the occupants of counter positions. For example, the worker may find a manager demanding that persons cut corners and do not adopt safe procedures, but at the same time, expecting a reduction in accident rates.

3. An individual's expectations of his own role may be incompatible with his constructions of another person's expectations. This phenomenon is interpersonal and concerns one's own behaviour in relation to others. For instance, the safety professional whose explicit duty is to prohibit the use of an important unguarded machine until it is safely guarded, may perceive a conflict between this duty and the expectations of the top management that he will subordinate that duty to crucial production demands in the workplace.

4. An individual's role expectations may be found to be incompatible with the behaviour of another. For example, the safety professional who always insists that persons wear hard hats in a particular area where there is a danger of falling objects, does not wear one himself when in that area.

5. Conflict also may occur as a result of an individual perceiving incompatibility between the expectations of different role incumbents of the organization as regards his own behaviour. A major factor causing this conflict appears to be the difference in values, norms, and rules of different persons in the organization. For example, a

worker's perception that his supervisor's expectations pertaining to his behaviour at work are different from those of the safety professional.

It is clear from the above that role conflicts are the results of individuals experiencing two or more simultaneous behavioural tendencies which are incompatible. It is possible for role conflict to exist even without awareness on the part of the individual. For example, such a situation can occur when there is ambiguity or a lack of definition of any role change.

D. Role ambiguity

Role ambiguity occurs as a result of a lack of clear understanding about the role tasks. Ambiguities can be experienced with regard to role expectations or to performance evaluation. These may be related to a lack of clarity of what one's duties are, what authority one possesses or how one is to be evaluated.

E. Role determinants and role problems relating to safety

No studies directly concerning role confusions relating to safety in industrial organizations could be found in the literature search. In this part of the report, it was therefore decided to present mainly examples of circumstances and concerns in industrial situations which may give rise to role conflicts and resultant confusions. These are dealt with under various subheadings.

1. External influences

A range of bodies external to the organization, such as regulatory and enforcement agencies, research and educational establishments, information centres, etc. through their respective functions, exercise a significant influence upon the role construction of positions within the organization. Some role confusions which may arise from legislation are used as an example here.

Formulation and the enforcement of standards and regulations governing health and safety in mines, enforcement and inspection functions, collection of records, and maintenance of statistics are some of the government responsibilities relating to mining safety. Legislation for mine safety imposes duties, liabilities, and various procedural and behavioural requirements as well as stipulating rights and entitlements of the occupants of various positions within the organization. These often form the primary basis of formal role prescriptions towards safety within mining organizations.

Until recent times, the approach adopted by legislation may be seen as one of paternalism. The duty to provide and maintain plant and equipment, personnel and safety systems were considered to be employer's who has the whole power of control over all the factors of production, including labour. The employer also carried out the policing function with regard to the behaviour of the employees within the organization. Enforcement philosophy was centred on the employer's right of control of the workplace and the work-force, whereas the workers obligations were derived solely from the concept of discipline and avoidance of injury to himself or others. Workers had no right to inspect, carry out other enforcement functions, or refuse dangerous work. During the last decade, this statutory pattern has been changing to incorporate worker participation in safety matters of organizations. Howells discussed the various basic forms that worker participation might take (*Howells,* 1974). They are:

1. *Monitoring of employees' and employers' compliance with statutory requirements and company standards and codes.*

2. *Acquiring and exercising the right to liaise with safety agencies and inspectorates.*

3. *Organizing and participating in mechanisms to incorporate worker involvement in dealing with safety problems at the workplace through communication, consultation, negotiation, and participation.*

The new approach therefore involves practically all the parties concerned with safety in the mines, both internal and external to the organization. It has been necessary for the interrelationships between these parties (role patterns) to undergo changes and adjustments which may sometimes have to be drastic. The relationship between a position and a counter position is normally formed around a set of complementary rights and duties. In this relationship, the rights pertaining to one position are often the duties pertaining to the other. However, legislation can stipulate only the principles, but cannot provide clear-cut and detailed descriptions of the nature of their interrelationships.

No piece of legislation can cover every contingency. What is possible to achieve is to prescribe those requirements which can be specified in legal form. It cannot provide a complete guide to what should be done. The detailed ways in which statutory stipulations applying to a particular organization are implemented in practice and the machinery established for compliance can vary between organizations. Incompatibilities may occur

between the interpretations of different role incumbents in an organization concerning legislation applying to specific situations and the practical ways in which compliance may be achieved.

2. The individuals' own perceptions

While prescriptions of formal role patterns towards safety in industry could be seen as arising from legislation, organizational structure, and organizational definitions of responsibilities and rules etc., it should be recognized that individuals in different positions come across concrete representations of those in a variety of forms and contexts. Factors such as personal background, skills and abilities, and past experiences would play an important part in this process. The personalized representations of the formal requirements would exhibit the variations as between different individuals occupying the same position.

The demands upon individual's actions come from various sources and consist of many aspects. Very often, one set of objectives are able to be realized only at the expense of another. Many personal factors and concerns relating to past experiences combine with emotional and subconscious aims of persons to contribute towards the goals and priorities of a particular individual. There is a substantial body of literature available on decision theory, dealing with the process of compromising goal achievement and factors concerning risk taking of individuals. (*Cohen*, 1960; *and Weil*, 1966).

3. Influences from other members of the organization

Homans described social systems in terms of activities, interactions, sentiments and norms (*Homans*, 1950). Individual actions are greatly influenced by their acceptability to the social group to which the individual belongs. Whenever there is a need to behave in a way which the group disapproves of, the individual is most likely to respond to the pressures of the group. Dubin et al pointed out that the social system controls of small groups are much more effective than the procedures of control devised by the large organizations of which the group forms a part (*Dubin et al*, 1965). To new employees of an organization in particular, receiving acceptance by the group would be very important. Some role expectations are constructed as a result of this informal organization as expected by and acceptable to the work associates of the individual.

4. Top management

The ultimate responsibility for running the enterprise rests with the top management. It has been a fundamental obligation of the employer to provide a safe environment in the workplace. This requirement is embodied in

various pieces of occupational health and safety legislation. However, to state that safety is a top management responsibility would be superficial. Although the overall responsibility for safety in the workplace lies with the top management and although this responsibility cannot be shared, co-operation of everybody in the workplace is essential for the effective discharge of that responsibility. The way in which job descriptions and functional responsibilities relating to positions in the organization are defined, is primarily dependent upon the perceptions and expectations of the top management. Factors influencing these expectations are a combination of a range of highly complicated sources such as the economic conditions, management philosophy and attitudes, legislative requirements, other organizational issues, etc. The ways in which these perceptions manifest themselves in the role descriptions of the organization may vary from one organization to another. As a result, there is little uniformity in the way top management carries out or provides to carry out its overall responsibility in practice.

It has been known that traditionally management in most organizations views safety as a function that is technical but separate from production and other management activities. One method that management has been known to adopt for the purpose of discharging their perceived responsibility and legal obligations is to assign the organization's health and safety responsibilities to specified safety personnel, who are not given any executive powers. The safety programs implemented by the management tended to be something dissociated from the production programs. The safety programs did not allocate much responsibility to the line management.

There are now the requirements that management declare and implement a policy which ensures the provision of a safe workplace for employees and that the policy should define the duties of all levels of supervision, specialists, and workers towards the achievement of that policy. It has often been said that compliance with the safety policy should be a part of rating the individual's overall performance. The need for top management to consider and promote its safety policy with the same care and enthusiasm as its policy for production and sales has also been emphasized. Whereas the descriptions of duties of different positions under the safety policy may form a basis for role expectations of individuals in the organization, the top management as well as other role incumbents' behaviour in practice could deviate in varying degrees from those stipulated. Incompatibility arising from these can be the source of role confusion and conflict amongst the occupants of most positions in the organization.

5. Line management

The line management, in general, exercise control, direction and authority over a section of the work-force or organization and is responsible to the top management for the proper functioning of the unit that they are in charge of. The goals and norms for the functioning of the system as a whole and its various sub groups and components are sanctioned by the higher management. They include mechanisms for social control and feedback circuits in order to insure adherence to their norms and attainment of the goals. Line management activities take place within the boundaries thus set. The way the line management perceives the rules, policies, and practices formally laid down by the top management would prescribe the functions of different positions of the line management.

Traditionally, safety functions had been considered as the responsibility of specially appointed safety personnel who carried out safety audits, inspections for hazard identification and reporting, accident investigations, etc. The primary function of the line management was seen as production. However, the concept that safety functions should permeate the whole system as thoroughly as production functions has been increasingly introduced in organizations. Through the implementation of a safety policy, the line management is being explicitly assigned safety functions within their areas of responsibility, with the safety professionals acting in an advisory and supporting capacity.

As a result, it is likely that the interrelationships between a line management position and a safety professional, as well as each of the other counter positions such as workers, top management, specialists, and other line management positions, would be affected. Also, the present day foreman, unlike his very early counterpart, is very much dependent on and greatly influenced by various elements of the organization (*Hesseling*, 1966; *Thurley and Hamblin*, 1963, *Thurley and Wirdenius*, 1973). These tend to introduce further complications towards role patterns within the organization.

Whilst the concept that 'safety is everybody's business' is being adopted, some of the accident prevention activities today may tend to move towards more and more specialization. Production goals and schedules established by top management may not have taken into consideration their practical effects upon safety and health at the workplace. For example, supervisors who find the need to enforce job pressures upon workers to meet production demands, may find incompatibilities between that and safety at their workplace. It is very likely that different members of the organization would use different frames of reference for their expectations. Maier *et al* found that even if a man and his superior were in agreement concerning the content of the former's job, they frequently disagreed regarding the

priority which should be accorded to the various duties (*Maier*, 1961). Sykes confirmed that there could be considerable conflict between the values and beliefs, imparted through training of supervisors and those of top management (*Sykes*, 1962).

Uncertainty and misunderstandings can easily occur between the occupants of different positions when the relevant responsibilities are not clearly understood. Apart from uncertainty regarding one's own duties and responsibilities, the situation could be further aggravated by the perceptions of the duties and responsibilities of other role incumbents. Renken and Lawrence found that differences in assumptions (orientations) between the occupants of different positions were related to difficulties achieving collaboration (*Renken and Lawrence*, 1952). Kahn *et al* in their studies on organizational stress found that 35 per cent of respondents were disturbed by the lack of clarity concerning the scope of responsibility of their jobs (*Kahn* et al, 1964). Lennerloff pointed out that it is very common to find conflicts between expectations held by different parties in the work situation (*Lennerloff*, 1968).

6. Safety professionals

The formal responsibilities of safety professionals are defined by top management through job descriptions and safety policies. These form the basis of formal role constructions relating to these positions. The formal position of the safety professional has been undergoing a change, in some organizations, from the person responsible for safety in the organization, to adviser to management on safety matters. However, incompatibilities can occur in the way this position is perceived by occupants of other positions in the organization.

The position of the safety professional can take a wide range of forms. Examples are, part-time duties by a line manager carrying out another full-time function, a full-time non-qualified ex-employee of the organization, a qualified professional, or a member of a well organized safety department in the organization. During the discharge of these various functions, he often has to relate closely to the functions of practically all other positions in the organization and frequently communicate with them. The nature and the degree of support and backing the safety professional receives from top management could exercise significant influence upon the extent to which this position is viewed seriously by other role incumbents of the organization. Often top management's expectations of the safety professional's functions are based on what is perceived as important to top management, which may be very different from the perceptions of the safety professional or occupants of other positions. The resultant incompatibilities between expectations may lead to role confusion.

Another major influence moulding the expectations of those other role incumbents is the effectiveness with which the safety professional could advise persons with a great deal of expertise in their own activities. This is another area in which a substantial potential for incompatibilities in expectations could occur.

7. Workers
As mentioned earlier, the trend of legislation on safety in industry has been to move from the concept of the worker's obligation to avoid injury to himself and others, to one of worker participation in the total process of providing for safety at work. As a result, it has been necessary for management and workers to change their approach to work-force involvement in safety. The change has been from one of disciplining the worker (on the premise that accidents are a result of careless behaviour of work people), to one of consultation and cooperation. In other words, a real participation in the process of decision making at all levels.

The formal prescriptions of duties, functions, and responsibilities in response to this trend by the management and the nature of procedures and systems adopted, as well as the expectations of the parties concerned, are bound to be greatly influenced by complicated issues of industrial relations and existing role constructions related to the process of consultation. These are areas with great potential for the occurrence of incompatibilities between the expectations of different parties concerned, particularly in the light of role expectations pertaining to existing machinery for negotiations and bargaining. Although, theoretically, safety may be considered as common ground for everybody and therefore noncontroversial, in practice this can be a highly controversial area, particularly when workers and managers consider the adequacy of the measures and rules and the attribution of blame when the rules are broken.

F. Effects of role confusions

Evidence from a large number of research studies (*House and Rizzo*, 1972; *Johnson and Stinson*, 1975; *Kahn* et al, 1964; *Gross* et al, 1958; *Miles*, 1976; *Greene and Organ*, 1973; *Rizzo* et al, 1970) have suggested consistently that both role conflict and role ambiguity are related to various negative personal outcomes. The following is a list of the major outcomes identified by these and other studies.

1. Job dissatisfaction

2. Job-related tension and anxiety

3. Reduced performance and effectiveness

4. Greater propensity to leave the organization

5. Low confidence in the organization

6. Unfavourable attitudes (lower levels of trust, liking and respect) toward role senders.

Tosi found that role conflict was also positively related to job threat (*Tosi*, 1971). Cohen concluded that ambiguity of the situation and inconsistencies of directions raised the anxiety of subordinates, caused a less favourable attitude toward supervision, and lowered productivity (*Cohen*, 1959). However, there is some evidence suggesting that different types of individuals respond differently to role ambiguity and role conflict (*Kahn* et al, 1964; *Lyons*, 1971; *Johnson and Stinson*, 1975).

Sanders *et al* in a study on the *Effects of Organizational Climate and Policy on Coal Mine Safety* concluded that, when decisions are decentralized, when management is flexible and innovative in trying new procedures and programs and when morale is high, disabling injuries decrease (*Sanders* et al, 1976).

Several researchers found that the primary problems for those in managerial roles may arise from lack of clarity in their job (*Hamner and Tosi*, 1974; *Rizzo* et al, 1970; *House and Rizzo*, 1972).

Some of the above findings and the theoretical bases supporting them, indicate that role ambiguity is a product of the organization and its environment. Examples of these are the extent of change or turbulence affecting the organization, degree to which job behaviour is specified by formal rules, standards, policies, etc. clarity and consistency in organizational communication.

Lyons found that role clarity experienced by individuals was directly related to satisfaction and inversely related to tension, propensity to leave and actual voluntary withdrawal (*Lyons*, 1971).

A general conclusion of the studies which have considered both role conflict and role ambiguity is that the relationships between role ambiguity and personal outcomes are generally stronger than those for role conflict (*Kahn* et al, 1964; *Miles*, 1975; *Miles*, 1976; *Rizzo* et al, 1970). There is strong

evidence from a variety of empirical samples that role ambiguity may be more pervasive than role conflict in its effect on personal outcomes.

Job stress in various forms has been identified as the direct outcome of role conflict and role ambiguity. There is much literature available on the effects of stress on the health of a person which can be mental or somatic (pertaining to the body) ranging from minor ill health to major illness. Examples of related somatic disorders are muscular aches, indigestion, and other bodily ailments such as infections of the upper respiratory tract, skin conditions and some cardio-vascular disorders.

Job stress has also been related to behavioural symptoms of persons such as quarrelsomeness, poor work, accident liabilities, prolonged or repeated uncertified absences, or frequent job changes (*Thomae*, 1963; *Davids and Mahoney*, 1957).

Unlike the case of mental or somatic symptoms, these undesirable behaviour characteristics have important implications towards other persons with whom an individual has to work, who then may react in various different ways. Very often the attitude adopted by management, co-workers or specialists is to treat that behaviour as an indication of lack of discipline, for which the appropriate remedy would be considered as measures for disciplining the individual.

In addition, tension, dissatisfaction, anxiety, reduced performance and effectiveness can all result in the individual's ability to cope with the situational demands concerning environmental and performance aspects of the workplace. Many researchers on accidents and accident causation have postulated that if the situational demands exceed the ability of the individual to cope with the situation, accidents will happen (*Hale and Hale*, 1972; *Surry*, 1969).

In a study of the role of the first line supervisor towards safety in the construction industry, Abeytunga found that supervisors imposed boundaries and limitations to their own safety role expectations (*Abeytunga*, 1978). They adopted a reactive approach, as opposed to a careful and thorough-going approach, in dealing with safety problems. They coped with role ambiguity and conflict towards safety in the following ways.

1. *They categorized certain safety functions as not fully within supervisory duties.*

2. *They perceived and expressed uncertainty or lack of authority to deal with some safety problems.*

3. *They accepted certain hazards at the workplace as inherent and inevitable characteristics of the particular industry.*

4. *They expected individual work people to cope with hazardous situations instead of removing the hazards.*

5. *They viewed complying with legal requirements as the ultimate aim of their safety effort.*

Low confidence in the organization, unfavourable attitudes towards role senders and greater propensity to leave the organization, are some of the effects on organizational aspects of safety performance arising from role conflict and ambiguity. It may be postulated that the following negative effects may arise from these outcomes–effects which have been identified as significantly important for the performance of an organization.

1. *Management's commitment to safety may be diminished.*

2. *Management's support and involvement in safety may not take place effectively.*

It can be seen that role conflicts and ambiguities can affect the physical and mental well-being of the person or groups concerned. They have also been found to give rise to a range of outcomes which may in turn have negative effects upon the safety performance of an organization.

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Rock mechanics and mine safety

October 1980

The Commission retained Professor Peter Calder, Head Department of Mining Engineering, Queen's University, as a consultant on ground control. Dr. Calder holds a Ph.D. in mining engineering, has a specialists designation in mining – Rock Mechanics, A.P.E.O. He is Chairman, Canadian Advisory Committee on Rock Mechanics Underground Blasting Sub Committee.

Introduction

I have been asked by the Commission to comment on several rock mechanics related matters as they pertain to the present inquiry. The increased incidence of ground fall related accidents in recent years is a particular concern. Hazardous rock conditions are often the result of the natural geological conditions present. They can also result due to improper mining practices, such as over-blasting and the incorrect orientation of openings in the *in-situ* stress fields present in rock masses. There is a need to develop ways of anticipating naturally occurring poor ground conditions, so that remedial measures can be taken, and to ensure that mine operators have the engineering skills and tools necessary to minimize ground control problems.

In moving to meet these objectives the following matters need careful consideration:

1. Is there a sufficient supply of trained engineering specialists in this field and if not how can the supply be increased?

2. What type of instrumentation is currently available to detect loose rock and rock movements? Which systems have the greatest potential for future development?

3. Should formal inspection systems of ground conditions in operating mines be instituted and if so how should they be conducted and what type of training should be provided to the persons involved?

My responses to these three questions are the subject of this report.

Supply of rock mechanics engineering specialists

It is well known that in Canada, at the present time, there is a severe shortage of mining engineers. This has been a problem for at least the last decade. This shortage is even more acute when one looks for engineers with post-graduate training in mining related subjects, including rock mechanics.

A mining engineer graduating this year will have many attractive job opportunities in the industry. Their salaries are generally quite high in comparison to other engineering disciplines. It is very difficult, even for those so inclined, to spend an extra year at the university to obtain a Master's degree because of the loss in immediate earnings that would result. Also, an engineer immediately upon graduation is short on practical

experience and may be well advised to spend some time in an industrial environment before pursuing graduate work. It becomes even more difficult for an engineer, having spent several years in industry, to return to university because of the severe financial penalty that would be incurred personally. Universities have difficulty in attracting sufficient numbers of graduate students in mining related disciplines largely for these reasons.

On the other hand, the universities do presently have adequate staff and facilities to produce post-graduate mining engineers with a specialty in rock mechanics. The time required for these programs is approximately eight months at the university, with an additional four months to complete a thesis topic, much of which time could be spent back in the industry.

For a student with a non-mining engineering degree wishing to obtain a Master's degree in mining engineering with a specialty in rock mechanics, the program would consist of two parts: a preparatory year during which the candidate would take basic mining engineering undergraduate subjects, and a summer in industry, followed by a normal eight months course program and four months of thesis preparation.

There are some relatively attractive scholarships available, both from government and industry, to sponsor post-graduate work in engineering. However, these are limited and are usually distributed on a highly competitive basis with emphasis on academic performance at the undergraduate level. It has been my experience that mining engineering, being a highly pragmatic subject, does not tend to attract often those with exceptional academic grades. It does tend to attract practically oriented engineers who are, in my opinion, ideally suited to this type of work. However, these people do not do well in competitions with disciplines such as engineering physics and chemical engineering for the available scholarships. As a result, this type of funding is not often available for those wishing to pursue post-graduate degrees in mining engineering.

The universities have some funding available through their own sources and through government and industrial grants and contracts. The average rate of remuneration for a student being paid from one of these sources at the present time is approximately $600.00 a month. By way of comparison, the average starting salary for a mining engineer graduating this year will be approximately $1,750.00 per month.

I believe there are two obvious and easily implemented solutions to the problem of attracting mining engineers to post-graduate programs:

1. The mining industry should sponsor young engineers with one to two years' experience who have been identified as having high potential and interest in this field. Mining engineers, in this category, could return to university for an eight month period under the sponsorship of their companies, possibly at full pay. These students could work on post-graduate research projects which are of special interest to the sponsoring company.

2. Government and Industry should be encouraged to support rock mechanics research at the universities on a contract basis so that the research conducted meets the specific goals of the sponsoring agencies. Research conducted in-house by government agencies is not as effective in training mining engineers as is research funded through the universities. Remuneration provided for graduate students in such contracts should be at a high enough level to attract suitable candidates. Current rates of support, especially those defined by government granting agencies, are not high enough to attract such students.

I believe that the use of this approach would be very beneficial, both to the mining industry and to the universities, and is definitely capable of solving the manpower shortage in a very short period of time. This program can be virtually implemented without delay, requiring only a commitment from the mining companies to sponsor these efforts. I believe this will provide a continuous stream of post-graduate mining engineers with rock mechanics research specialties in the areas of prime concern to the Canadian mining industry.

As to the role of rock mechanics engineering specialists within a mining operation, I believe they should be integrated into the normal mining engineering stream. All aspects of mine design, planning and operation involve rock mechanics considerations. A mining engineer, during his career, will progress through various operations, engineering and management functions. A specialized knowledge of rock mechanics will be an asset in all these roles.

The mining engineering department of most large mines should include an engineer with specific duties for rock mechanics aspects. He should have a number of technicians working for him as required by the circumstances. This unit would be responsible for ground control inspections and monitoring and have rock mechanics input into design and planning. The engineer in charge of this group should be a rock mechanics specialist but this assignment should be a stepping stone in his career, not a permanent assignment.

Most large mining companies should continue to use the services of widely experienced consulting engineers to review and coordinate the broad aspects of their ground control program. There are three main reasons for recommending this as an alternative to developing a total in-house capability:

1. A consulting engineer has the opportunity to study a wide variety of problems and the experience gained in one situation is often partly transferrable to the next. An engineer working with a relatively unchanging set of circumstances does not have the same perspective. It would be necessary for an engineer to travel widely visiting operating mines, research institutes etc., and attend many conferences to keep fully abreast.

2. Experience has shown that if companies do develop highly trained specialists they will be unlikely to hold them for long periods of time. This can leave the company in a situation where the only person who was involved in key technical decisions is no longer available.

3. It will probably be more cost effective in the long run, as most companies would not require the full time services of a senior rock mechanics engineering specialist.

Loose rock detection and monitoring systems

When unstable ground is known to be present, the loose rock must either be removed from the solid rock or secured to it using artificial reinforcement. Accidents occur when loose rock is either improperly supported or goes undetected. Following is a review of current and potential methods of detecting loose rock in underground mines.

(a) Visual inspection
Visual inspection is often the primary method of detecting loose rock. It will never be possible to detect all potential loose rock hazards using visual inspection, but it is the most effective way of observing conditions over a wide area and should always be included in any inspection program.

Good lighting is obviously an important part of any visual inspection system. There is a need for a hand-held high intensity source of light to properly conduct these inspections. The required light source is fortunately readily available. The Mining Industry Research Organization of Canada (MIROC) has developed a 12 volt ten cell nickle cadmium battery pack for use with an improved cap lamp and helmet in underground metal mines. The standard battery pack in this unit is readily compatible with commercially available, high intensity 12 volt spotlights.

The light used with good success at Cominco's Sullivan Mine has the trade name 'Show-Me'. It is manufactured by Able 2 Products, Cassville, Missouri, Model no. 375, having 110,000 candle power, and it is available through Canadian Tire outlets. This light has been used to inspect mine roofs 90′ high with no difficulty, it is reportedly a valuable aid in spotting loose rock. It consists of a hand-held bulb with a 3′ long cord attaching to the standard MIROC battery pack. Cominco reports that the light is capable of operating continuously for approximately 1½ hours on a single charge of the MIROC battery. This is probably adequate for a normal shift, as the light would often be shut off.

A paper based on a recent survey conducted by the South African Department of Mines[1] reported that in excess of 50% of the fatalities in underground mines were caused by rock fall accidents. The study involved the perception of rockfall hazards by trained and untrained workers. An analysis of non-rockburst related rockfalls was done to determine the appearance and likely location of rockfall prone areas. The test was carried out in a simulated work area with miners grouped by their experience. It was found that experienced miners could visually perceive an unsafe condition better than a novice but not as well as a novice that had been trained.

Visual inspection is the first and probably the most important method of detecting loose rock. The problem still remains that not all unstable rock can be visually identified.

(b) Sounding (scaling bar)
The scaling bar is a very useful apparatus for detecting small pieces of loose rock by experienced and trained miners. A paper written by the Swedish National Board of Occupational Safety and Health[2] sets out guidelines for the use of a scaling bar. The effects of striking a rock mass with a scaling bar are well known to experienced miners. In general, solid rock causes the bar to give off a ringing response when it is impacted. A dull response indicates loose wedged in pieces of rock and as a rule is accompanied by a muffled sound or echo. It is often possible to feel the vibrations of loose rock when placing the fingertips on the surface of the rock while striking it with a scaling bar. Larger pieces of loose material, thick blocks and rock slabs, etc., also give a ringing response because of the large mass when impacted with a scaling bar. It has also been observed that steeply dipping fractures (over 40°) do not generate echo effects. Softer rocks, or rocks which are highly fractured or decomposed, do not always give the characteristic ringing response when impacted by the scaling bar and it is therefore more difficult to detect hazardous conditions in these types of materials.

There is, in my opinion, the potential to develop a spring loaded calibrated impacting device that would serve the same purpose as a scaling bar but provide more quantitative information.

This technique together with visual inspection is the most widely used method currently available to detect loose rock. These systems will remain important in the foreseeable future; however, they are not capable of identifying all situations where loose rock is present.

(c) Vacuum hole inspection
A vacuum hole system of monitoring fractures in mine roofs is being investigated by CANMET.[3] It is based on the theory of gas migration through a porous medium. The use of a vacuum test hole and a communication hole will determine if an open fracture exists across a rock mass. Although not yet extensively field tested this method appears to possess good possibilities for locating major structural separations in mine roofs. Instrumentation is simple but requires the drilling of monitoring holes on a regular pattern throughout the working area. If holes are positioned correctly this method should detect the existence of a 'coffin roof' or similar potentially hazardous situation. This method would probably find application as a backup method for detailed inspection of suspected unsafe conditions observed through other loose detection techniques.

(d) Seismic waves
Seismic waves are altered in three ways by the presence of fractures in rock masses; reflection, transmission velocity reduction and amplitude attenuation can each provide structural information but require careful interpretation and extensive instrumentation. Generally the equipment used to conduct these types of studies has been extremely bulky and expensive, requiring skilled operators and sophisticated computer analysis of the data.

Recently a new type of seismic system has been developed which has increased greatly the capability of conducting seismic studies in noisy areas such as in operating underground mines. A portable signal enhancement seismograph, in which seismic waves from impact sources are stored and summed, is currently commercially available and is presently being tested by the Mining Engineering Department at Queen's University as a practical tool for detecting loose rock underground. Preliminary test work has been encouraging but much remains to be done. It is anticipated that the evaluation of this system, as a reliable portable method of detecting loose rock underground, will be completed by the end of 1981. The operating principle is that the reflected waves from repeated impacts on a surface are stored and summed together so that random background noises are cancelled

and therefore the signals reflected from loose rock surfaces are enhanced with repeated impacts. The work at Queen's University is being sponsored by the Mining Industry Research Organization of Canada (MIROC).

Although a great deal of testing of other seismic systems has taken place throughout the years, to my knowledge there are no operating systems which are currently being used on a routine basis by the mining industry.

There may be the potential for seismic systems operating in the audible range to detect loose rock, although a viable system is not available at present. This would possibly involve the use of a hand-held electro-mechanical vibrator operating in the 100 to 10,000 Hz range and a headset receiver.

The U.S. Bureau of Mines[4] is currently sponsoring the development of a micro-seismic system, operating in the 40KHz–100 KHz range, to detect the onset of rockfalls. It consists of a lithium sulphate crystal pickup attached to the wall of a mine opening which detects the number and energy level of micro-seismic events. Several minutes before final failure a continuous micro-seismic signal is generated by the failing rock, providing a clear warning in the tests conducted in U.S. coal mines. The rock falls observed were in the 10,000 yd^3 range and were precipitated by pillar removal. This instrumentation has a detection range of up to 500′ and appears to have good future potential as a roof fall warning system.

(e) Infra-red systems
Because loose pieces of rock are not fully coupled to the host rock, they could be at a slightly different temperature than the surrounding rock mass. This is due to the effect of the cooling mine air and occurs when there is a significant temperature difference between the ventilating air and the rock mass. However, various mineral compositions will have different thermal coefficients and this will also cause some temperature differences on the surface of mine openings. This method has been evaluated over a number of years by the mining industry both in Canada and the United States[5] and has not found wide acceptance to date. One reason is that the temperature of the mine air is often close to that of the surrounding rock and large temperature differences between loose and solid rock often do not exist. There is a possibility that some type of pre-conditioning of the surface of mine openings, such as heating or cooling them prior to the inspection with an infra-red device would make this method more practical. This could possibly be done by shutting off the mine air in a section that was to be inspected for a period of time, to allow the rock temperature at the surface of the mine openings to return to its natural value. If ventilating air is

introduced with a considerable temperature difference, the effectiveness of the infra-red system would be greatly enhanced. However, considerable research is needed to confirm this.

There are infra-red instruments now available which can detect temperature differences of 0.1°C, such as the 'Probeye' system manufactured by Hughes Industrial Products Division, Carlsbad, California.

(f) Rock mass classifications
An important part of any ground control program is to anticipate areas in the mine where problems would be expected due to the natural rock conditions present. The use of historical data relating rock properties to stability experience can greatly aid in predicting the location of problem areas. There are several rock mass classification systems currently in popular use, such as the one proposed by Bieniawski.[6] These rock classifications are commonly used in civil engineering designs to estimate the degree of reinforcement required in rock tunnels, etc.

Some mining companies have developed their own classification systems to forecast areas of potential instability.[7] Drillhole control and geological interpretations are used to determine the type of rock on future working faces. This information is then correlated with historical data to forecast unstable roof conditions. The mine design is altered to take this into account. This method has been successful at the Beckley Mine in reducing rockfall frequency by 80%.

(g) Displacement monitoring
Rock mechanics instrumentation is available which can measure ground movements and stresses in underground mines.[8, 9]

A recently developed system[10] consists of an extensometer of variable length inserted in a borehole in the roof of a working mine. An instrument connected to the base can be set to detect a predetermined amount of movement and transmit a radio signal when this amount of displacement is exceeded. The signal is picked up by a small radio receiver in the possession of the miner and he is warned of the danger. Another alternative is the permanent installation of receivers along working mine areas to receive signals from various transmitting heads and warn automatically of any appreciable movement by triggering an alarm signal.

A similar mechanical device consisting of a spring loaded head attached to a rock bolt can be used to trigger a warning following a predetermined

amount of rock movement. This device, known as 'The Spider' is manufactured by The Spider Inc., St. Louis, Mo., and has apparently been successfully evaluated by the U.S. Mine Safety and Health Administration.

(h) Borehole inspection
Borehole periscopes and television cameras have long been available but are not practical for use on a routine basis.

A simple feeler gauge has been used successfully in coal mines to detect separated beds in boreholes. This consists of a metal rod with a protruding piece of spring steel attached to the tip. The rod is inserted in the borehole with the spring steel tip pushed slightly against the wall of the hole. The rod is pushed up the hole and if an open fracture is encountered the feeler tip will enter the fracture. It is possible to lower the rod up and down and determine the thickness of the open fracture. This device may have some merit as an inspection tool which would routinely be used to inspect all rockbolt holes prior to the insertion of bolts. Some holes could be drilled to greater depths in areas of concern to ensure that bed separations are not present above the rockbolt anchorages.

The development of a gamma ray probe for inspecting rockbolt holes has recently been announced by Australia's Commonwealth Scientific and Industrial Research Organization. The main purpose of the probe is to determine whether the rockbolt holes have reached firm competence strata, providing a sound anchorage for the rockbolt. The hand-held probe, known as 'Stratasnoop', is pushed into the borehole and is capable of detecting differences in the quantity of natural gamma rays given off by different rock types. A radiation count is recorded by the probe and indicates whether or not the hole has bottomed in a competent bed of material, such as sandstone. This device may have the potential for spotting cracks in the strata as well, but this apparently has not been evaluated to date.

Inspection of ground conditions

Some form of ground control inspection system will be a vital part of any good ground control program. This would include a visual inspection of all active working areas of the mine, utilizing high intensity lighting and a scaling bar, as a very minimum.

Depending on conditions some form of borehole inspection of rockbolt holes and possibly of blastholes may be advisable.

The geological structure should be closely inspected and mapped as it is exposed in new areas, as this will provide a valuable source of information over the years in building up rock mass classifications which can identify potentially hazardous areas.

The various types of instrumentation which have been described, although not able to solve all the immediate problems of loose rock detection, do offer considerable hope for the future. Therefore, it will be necessary for mine operators to have skilled technicians available who are familiar with and capable of operating this type of instrumentation.

In addition, various types of monitoring and warning devices have application in various circumstances and there is every expectation that the reliability of this type of instrumentation will improve in the future.

Just as there is a shortage of skilled rock mechanics engineering specialists, there is also a shortage of rock mechanics technicians who could perform these types of inspections. It will probably be necessary to introduce a training program for mining technologists to become specialized in these areas.

Following is a suggested course outline for the training of persons in basic rock mechanics and ground control hazard identification.

Ground control course for mining technicians

(a) Rock mechanics
Basic rock physical properties and the behaviour of rock under the application of ground stress fields will be presented. Particular emphasis will be placed on typical rock stress conditions in underground mines and the way stress fields are concentrated by the presence of mine openings and structural defects, such as major faults. The conditions under which rock fails as a function of the stress level and the pertinent physical properties will be described. The distinction between a rock mass and a rock material will be emphasized.

(b) Basic geology
A description of various structural features such as faults, bedding planes, joints, dykes, etc. will be presented.

A classification of various rock types including Igneous, Sedimentary and Metamorphic will be presented. Typical suites of rock samples from various mining camps in the area of interest will be described in detail.

The candidate will be trained in various simple ways of identifying the rock types which would be encountered in the area of interest.

Rock classification systems, based on physical rock properties and structure, will be described in detail and case studies will be used to illustrate how these classification systems are used to broadly predict areas of potential instability.

(c) Basic surveying and mapping
Training in map reading and surveying will be included so that the candidate can locate himself underground and map hazardous fractures and loose zones on existing mine plans. A detailed knowledge of surveying instrumentation will not be required. Rather the emphasis will be on the use of such things as the Brunton compass, precision tape measurements, devices for measuring angles, hand levelling, etc.

(d) Mining methods
It is vital that the candidate have an understanding of the various mining methods currently in use with particular emphasis on ground control implications. This will include a review of the drilling and blasting procedures used in the various methods and the effect of blasting vibrations and overbreak on the stability of mine openings.

(e) Ground support systems
An awareness of the various types of ground support systems and an understanding of where they are applicable and what their limitations are will be developed.

This will include a discussion of both active and passive ground support systems. The various types of rockbolts and rockbolt testing procedures will be described. Simple examples of determining the appropriate amount of reinforcement for a given area will be developed, the use of mine backfill, grouts, steel sets, linings, hydraulic props, shotcrete, etc. will be included.

(f) Rock mechanics instrumentation
A basic description of rock mechanics instrumentation will be presented, this will include strain gauges, pressure gauges and cells, micrometers, extensometers and various seismic systems. The various instrumentation available for loose detection around mine openings would be included.

(g) Field studies
The candidate will be given experience in the identification of zones of

loose rock using such things as a scaling bar, geologist's hammer, and a borehole feeler gauge.

The candidate will be required to identify and map typical faults, dykes, shear zones, folds, ore contacts, etc.

Detailed mapping of major rock structures. This will involve the use of the Brunton compass, clinometer rules, tape measurements, etc., and the production of plans and cross sections upon which these structures would be indicated and extrapolated. An interpretation will be required and the recognition of potentially hazardous conditions will be part of this exercise.

The candidate should have some experience drilling holes through both fractured ground and ground where various rock types are present so that he will have a better appreciation for the types of information that a driller can obtain on rock conditions from the feel of the drilling process.

The candidate will be given experience in the installation of various types of rockbolts and in conducting rockbolt strength tests. The candidate will conduct a simple stress measurement test using a door-stopper gauge.

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The economics of a 'margin of safety' in mine production

December 1980

The Commission retained Basil Kalymon, Professor of Finance, University of Toronto, School of Business, to analyze the concept of the 'Margin of Safety' and its economic implications for the mining industry generally. Professsor Kalymon is the director of the school's Natural Resources Management Program. He has a number of publications including the recent text – *Canadian Resources Management: Concepts and Cases*.

1. Introduction:

One of the largest metal mines in Ontario also has one of the best mine safety records for the Province. While many elements contribute to mine safety, one of the factors credited for the good safety performance is the concept of a 'margin of safety'. This concept is defined as 'the amount of extra capacity available to make up or prevent a production loss caused by a major unforeseen outage'. This 'margin' permits all levels of employees, from manager to worker, to meet his assigned tasks or production quotas without taking risks to catch up. It is defined on the one hand by the investment of money in extra equipment, facilities or inventories which determine the flexibility and capacity of the mine and on the other hand by the setting of production norms and performance evaluation standards.

The key relationship which affects the margin of safety is the production capacity of the mine as related to the capacity of the mill. Given the capital intensity of the mill investment, the production quotas of the mine will be determined by the ore feed requirements of the mill. Once constructed, shutdowns of a mill become extremely costly and pressure will be exerted on mine operating personnel to provide the requisite production. Lacking adequate equipment, mining facilities or ore inventories, shortcuts in maintenance or mining procedures or worker fatigue resulting from attempts to catch up to production quotas, may increase the likelihood of mining accidents.

The provision of a 'margin of safety' may, however, be viewed not only as an accident prevention measure. The provision of the extra capacity and inventory investment required, may in fact be viewed as an insurance premium against the financial losses which may be incurred as a result of shutdowns of the mill due to a lack of feed ore from the mine. In many cases, extra-capacity or redundancy may, in fact, be justified simply as a matter of good economnics fully justifed by the revenue protection which this investment provides.

In this report, the cost/benefit tradeoffs of providing a 'margin of safety' shall be analyzed, based on a simplified characterization of the operations of the above mentioned large metal mine. The analysis is not intended to be comprehensive nor a completely faithful representation of the mine in question. Nevertheless, the analysis reflects the most critical elements which determine the 'margin of safety', the orders of magnitude of costs involved and the nature and size of the economic losses which may be avoided. While the trade-offs implicit in the structure and choices made by a single mine are presented, the factors which can alter these trade-offs in other mines are also analysed. A discussion of the applicability of a

profitability-based justification of providing a ‘margin of safety’ in both existing and yet to be developed mining operations forms the final section of this report.

This study is based on information obtained through personal interviews, telephone interviews, annual corporate reports, articles from mining journals, summaries from the Canadian Mines Handbook and from statistical publications of Statistics Canada.

2. Economic considerations

2.1 Description of mining process

For the purposes of this study, all facilities upstream of the mill are designated as ‘the mine’ and the delivered crushed ore is referred to as the production from the mine. To gain an insight into the main elements of mine investment and the potential sources of disruption of mine production, the mining process will be described by the schematic divisions shown in Exhibit 2.1.*

The analysis of a margin of safety assumes that a prior determination of the most suitable mill capacity has been made. This determination is presumably based on the trade-off between the size of the mill and the lifetime of the mill, given the size of the ore body. Furthermore, it is assumed that a mill of a chosen capacity has been built.

A potential stoppage or restriction in output from the mine (after Step 8) can occur for a wide range of reasons and effectively through the breakdown or limitation of production at any step in the process from the development drilling to secondary crushing. Clearly, the capacity of mine output is limited by the capacity of each critical processing step.

In a sequential production process, disruption of a single step can lead to a de-activization of following steps as input feed of semi-processed ore is interrupted. Such losses in production at any step can be avoided through the maintenance of inventories or ‘reserves’ of ore at different stages of processing. Specifically, for the mine described, Exhibit 2.1 also describes the nature of the alternative in-process ore inventories or reserves which may be held. The greater the level of inventories held, the greater the protection provided against losses of production at any step or ultimately against shortages of mill feed which would result in product losses.

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*See page 128.

Inventories alone, however, in the absence of extra production capacity in the mine would not be effective. In order to build-up in-process inventories, either initially, or as a replenishment when they have been used up to maintain production during the disruption of any given step of the process, mine capacity in excess of that required to provide feed to the mill must be available. Otherwise, while normal levels of mine production might be resumed, replacement of these in-process buffer inventories could not be accomplished. Of course, speed-up procedures or temporary increases in manpower or equipment could be used–possibly at the risk of accidents.

Similarly, production capacity in excess of mill-feed requirements cannot by itself assure against stoppages in mine output. If, for example, the hoist becomes inoperative then, lacking appropriate inventories of crushed ores at the surface, the capacities of either the surface or underground mine facilities would be useless in preventing losses in product output.

2.2 Costs of the margin of safety

As seen above, both mine capacity in excess of mill-feed requirements and the inventory levels of in-process ores are the elements which create the 'margin of safety' which permits the mine production requirements, as set by mill capacity, to be met without undue stress. These capacities or inventories cannot be provided without cost.

In defining costs, we shall consider these in the context of an average operating year of the mine. With regard to the extra production capacity of the mine, the principal costs involved are the capital expenditures incurred for this excess capacity. These can be identified mainly on the bases of the major pieces of equipment which are used at each step of the mining process.

In defining an annualized cost equivalent, two separate considerations are required–the cost of capital to the mine and the depreciation as determined by the effective life-time of the equipment. The first factor can be determined by general evaluation of the cost of borrowed and equity funds to mining operations or by a specific assessment for any particular firm. It defines the opportunity cost of investing in the extra capacity. Given the current state of financial markets, which reflect the expected rates of inflation, a cost of capital of at least 15% for an established operating mine may be reasonable to use. Higher rates would be applicable if the mine is still under development or its reserves are questionable.

The other factor, namely depreciation, requires the determination of the effective life-time of the equipment. This will generally be the shorter of the useful life of a given type of equipment or the remaining life of the

mine. While the former is determined by engineering design standards, the latter will vary with the size of the known reserves of the mine in relationship to the rate of mine production.

The well-known theory of present-values and discounting establishes the following annualized equivalent cost:

C = Capital expenditure amount ($).
r = Cost of capital (%).
n = Effective life-time (yrs).
A = Annualized cost equivalent ($).

$$A = C \times r \times \left(\frac{1}{1 - \left(\frac{1}{1 + r} \right)^n} \right) \qquad (2.1)$$

This can be easily interpreted as simply the capital amount expended (C) times the cost of capital (r), C x r, if the equipment is to last indefinitely. Otherwise, a component of cost related to the need to recover the initial cost is added by the remaining factor of the expression in (2.1).

In consideration of the in-process inventories which must be carried to provide a 'margin of safety', the costs which must be considered are the opportunity costs incurred by the investments required in labour, materials or equipment to develop these buffer stocks. In-process inventories do not depreciate in the same manner as investments in equipment since the full amount of inventory investment would presumably be recoverable upon termination of operations. In fact, inventories of ore may even appreciate in value with inflation. Consequently, the annual cost of carrying in-process inventories might be described by the following:

ℓ = Cost of a unit of inventory ($/ton).
L = Level of inventory (tons).
r = Cost of capital (%).
i = Rate of inflation (%).
h = Added handling costs of inventory ($/ton).
B = Annual cost of carrying inventories ($).

$$B = \ell \times L \times (r + h - i) \qquad (2.2)$$

where h represents the possible additional annual costs of handling ore incurred due to the maintenance of inventories such as possibly turnover requirements, provision of storage capacity, etc. If inventories are held at different levels the cost of inventories will vary with the degree of processing already incurred. Thus, broken ore underground costs less than

crushed ore in surface bins due to the additional costs in processing already incurred for the latter.

2.3. Benefits gained from prevention of stoppages

The prime economic benefit gained from having extra mine production capacity and in-process reserves of ore is the protection which this provides against the interruption of product output from the mill. To appreciate the penalty which a day's stoppage of a mill may entail requires a decomposition of the components of the revenue stream as shown in Exhibit 2.2.* For an existing mine and mill, in the short-run, say for 1 to 30 days, essentially *all* of the costs can be considered to be fixed and payable regardless of the level of output. Thus, for example, unless labour is strictly on a piece-work payment basis or can be laid-off without notice, the wage bills will continue to be payable even if no work is being done. Similarly, depreciation of the existing plant will not be noticeably decreased if the mine or mill cease to operate for a brief period of time. Administrative costs, presumably dominated by salary payments will also continue during a stoppage as will interest payments due on loans. Material costs appear to be one exception, but generally would not constitute a major portion of the expenditures of a mine. Finally, corporate profits would appear, initially, to be a second exception.

However, corporate profits must properly be viewed as a foregone opportunity cost to the firm. For each unit of foregone current ore production, the profits which could be realized from that unit of ore are delayed to a future period. This future period may in fact occur only at such a time when the foregone unit of production extends the life of the mine. Thus, if the known ore reserves of the mine are large, the opportunity delay in profits is essentially indefinite. If the known reserves of the mine are small, the lost profits may be recovered in a shorter time period providing, however, that the production losses do not lead to premature closure of the mine. From the corporate perspective, the portions of profits payable as Mining or Income taxes would not constitute an opportunity loss, however, corporate taxes saved through cost expenditures would then also need to be considered. Our analysis will be restricted to a pre-tax analysis of both costs and benefits.

Over a longer stoppage of production from the mill, some of the costs entailed would become variable. In such a circumstance the penalty of stoppage of production is reduced accordingly. For example, with layoffs, labour costs may be reduced decreasing the opportunity cost accordingly,

*See page 128.

salaried employers may be fired, and depreciation charges may decrease with an extension of the useful life of some assets.

Of course, if the mine is yet to be developed, the only opportunity costs of lost production are the potential corporate profits which are being deferred to future periods. Under such circumstances all other costs must be considered to be variable.

In summary, an initial assessment of the losses from stoppages of product output from a mill must be considered to be as follows:

r = Cost of capital (%)
d = Days of stoppage (days)
t = Production rate of the mill (tons per day)
R = Gross revenues per ton (\$/ton)
n = Life of the mill
P = Corporate profits per ton (\$/ton)
S = Total cost of stoppage.

$$S = d \times t \times \left(R - \frac{P}{(1 + r)^n}\right) \qquad (2.3)$$

In the above, it has been assumed that over the long-term life of the mine product prices and markets are uncertain but we shall presume that the level of profitability will not be substantially different in the future. While reasonably valid historically, the current level of inflation may in fact reduce the effective penalty of delayed production due to the rise of profits per unit produced in the future.

2.4 Reliability

A further important consideration entering the comparison of costs and benefits from the provision of a margin of safety concerns the degree of reliability and length of likely disruptions. If a particular step of the mining process has a higher failure rate or has the potential for shutting down mill production for a substantial number of days, a higher degree of extra capacity or inventory protection can be justified. In general the benefits of prevented stoppages must be weighted by the probability of the occurrence of such a stoppage in the absence of a particular component of the 'margin of safety'.

Unfortunately, while normal unexpected downtimes can be recorded and measured, the rare occurrences of major failures requiring extensive repairs or equipment replacement cannot be readily quantified. Their infrequency

of occurrence implies that an operating mine may have only one or two such events in its entire history. Nevertheless, such disruptions constitute a major threat to the well-being or even survival of the mine and mill. Insurance against these events of unknown though low frequency may be viewed as a value which exceeds the expected cost of such losses.

Frequent disruptions, of themselves, may indicate a lack of control by operating management of the mining process. Confidence of both upper management and the mine workers may be a further intangible benefit of redundancy and back-up created reliability. This may, indirectly, have positive economic repercussions to the mine.

The degree of unexpected disruptions in any portion of the mining process is related to the maintenance program adopted. Low levels of regularly scheduled downtime for maintenance is likely to result in more unscheduled emergency repairs. Extra capacity in any given pieces of equipment in the mining process permits a more complete maintenance program. A properly balanced maintenance program should reduce the long-run 'downtime' of equipment through extensions of its useful life and avoidance of extensive downtime resulting from avoidable breakdowns. Furthermore, increased reliability of the system component is achieved through the reduction in unexpected downtimes, and the consequent need for underground repairs.

In summation, the reliability improvement provided by a given incremental component of the 'margin of safety' should be expressed in terms of the probability of a stoppage of a designated number of days which it prevents. If a stoppage of d days in mill production, for example, has a likely probability p of occurring during the year, then the expression for the value of avoiding such a stoppage is given as follows:

U = Value of preventing a stoppage ($)

$$U = p \times S + I \qquad (2.4)$$

where I represents the risk-premium which a firm is willing to incur in excess of expected losses to avoid exposure to the possibility of major losses of unknown but small probability. The higher the risk aversion of a firm, the higher is the likely risk-premium (I) which they will be willing to pay.

3. Numerical illustration

Based on the rough characteristics of the operations of the major metal mine referred to above, one can characterize the economics of the margin of safety. All cost figures and revenues are in 1980 current dollars and

reflect either today's replacement costs or current metal markets, respectively. No attempt has been made to consider possible fluctuations in past or future performance even though it is recognized that mining revenues are historically cyclical and unstable. Many approximations and simplifying assumptions have been made, but the essence of the economic potential of maintaining a 'margin of safety' is represented.

3.1. Characterization of capacity margins
The initial task is the characterization of both the required mill-feed production and the extra-capacity provided. These assessments for each of the key mining processes identified above in Exhibit 2.1 are shown in Exhibit 3.1.*

Clearly, excess capacity is a matter of definition. The definition depends not only on the amount of investment in equipment, but also on the operating and maintenance schedules assumed. Peak short-term capacity clearly does not reflect the available capacity over the longer term since no provision for downtime based on mechanical availability has been made. Generally available capacity, on the other hand understates potential capacity of a process since the operation of a third-shift or on weekends could increase production. It could be argued that the sum of unscheduled downtime and maintenance downtime may be invariable with reductions of the latter leading to an increase in the former.

From Exhibit 3.1, it appears that, for example, a large amount of excess capacity is available in the primary underground crusher, which has an excess of 26,320 (= 96,320 − 70,000) tons of ore per week under generally available conditions of two shifts operating for five days. In addition, 28,000 tons of ore could be processed on the third shift and a further 67,000 tons over the weekend. This total excess would provide a total of 173% (= (26,320 + 28,099 + 67,000)/70,000) extra capacity above mill-feed production requirements. Alternately expressed, 63.4% of the available crusher capacity could be considered as a 'margin of safety'. Similar computations for each process provides the determinations of the margins shown in Exhibit 3.2, on the basis of both 'total' and 'generally available' extra capacity.

It should be observed, that current manpower complements would clearly preclude the use of the total extra capacities for extended periods of time. Additional labour may, in fact, not be available for regular weekend assignment. However, over several months, reallocation of available labour

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*See page 129.

from other tasks, such as maintenance or any less critical operation could increase the output of a given process to the indicated levels. This increase in production could be used as a catch-up measure to rebuild any depleted inventory buffers.

For brief time periods it must also be recognized that maintenance time could also be reduced. This in conjunction with reallocation of labour from less critical tasks could further increase short-term catch-up capacity. Equipment failures, of course, would prevent this potential capacity to be used frequently.

It must further be recognized that even though the throughput capacity of any given component might be at the higher levels suggested by the 'margin of safety', total mine output would still be limited to the weakest link in the chain. Lack of available headings, the need to carefully blend the varying grades of ore and the restricted room for manoeuvrability would nevertheless restrict total mine output below the increased levels of capacity suggested by all-out application of the equipment available.

The extra capacity margins, however, do provide substantial catch-up capacity as indicated by the third column of Exhibit 3.2.* The 'Annual days of mill requirements' is a measure of the number of days of calendar day outages which could be incurred in a process during a year without impacting total annual production required. Of course, if mill output is not to be lost, substantial buffer stocks would have to be available to handle requirements during the outage.

The final column of Exhibit 3.2 indicates the level of investment in equipment or facilities required to maintain a 'margin of safety' in mine capacity. These values were computed as a simple linear proportion of the total investment costs shown for each process in Exhibit 3.1 by applying our % of peak capacity margin. At a limit, approximately $8.17 million of extra investment might be required to provide the extra capacity indicated.

3.2 Levels of in-process inventories

To establish the level of investments in in-process inventories used as surge capacity and protection against stoppages in mill output, one requires the levels of inventories provided at different stages and the cost of developing such inventories. For the above sample mine, the target and actual inventories used to provide a 'margin of safety' are shown in Exhibit 3.3.* The inventory protection of the underground processes of development, drilling

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*See pages 130/131.

and blasting can be seen to provide substantial number of days of protection against any outages in these operations. Partly, the level of these inventories is dictated by the nature of the mining process used in which large stopes are blasted at a single time. Nevertheless, a 'margin of safety' to provide ample time to catch-up to production quotas is provided by these reserves.

The following inventories are generally restricted to providing minor surge capacities, with only one or two days of production protection. The one exception is the 'surface stockpile' which clearly provides the major buffer between the underground mining process and the mill. Outages of the hoist, for example, would leave mill production strictly dependent on the surface stockpile if outages of longer than two or three days should occur.

The investments required in the inventories which contribute to the margin of safety are shown in the final column of Exhibit 3.3. These were determined by evaluating the inventories on the basis of the costs incurred up to the given stage of the mining process. These costs reflect full costs but include mostly labour expenses. To the degree that average inventories are held as indicated, the investment total reflects the amount of funds committed to inventory build-up.

Clearly, the combination of the extra capacity discussed above and the inventories held, provided total protection against stoppages in mill output. Over the past 15 years not a single stoppage of production in the mill has occurred. The effective reliability of the total mine production system has, in effect, been 100% in providing the targeted mill ore feed.

3.3 Costs and benefits assessments

The application of the measures of annual costs or benefits developed in Section 2, can be applied to the sample mine described above. For this purpose, we shall assume that the mine has an assured lifetime of 30 years which is derived from an annual production of 3.64 million tons of ore and an estimated ore reserve of 111.0 million tons. While a longer life may materialize with further exploration, economic planning should be based on assured reserves.

The determinations of the annual costs of maintaining extra capacity and inventories is shown in Exhibit 3.4.* These costs were established by applying equations (2.1) and (2.2) for extra capacity and inventories respectively. The assumption of a cost of capital of 15% per year was made

*See page 132.

with inflation running at 10% per year. An effective average life-time of 30 years was assumed which, while overstating the useful individual life of some of the smaller pieces of equipment, such as LHDs, reflects the lifetime of the fleet given the degree of spares available to prolong calendar life. With a long expected life of the mine, the extra-equipment can be seen to be amortized over a long-period of time. Also, a 2% cost of handling inventories has been included to reflect costs of storage on potential needs for turnover handling.

These annualized costs of the 'margin of safety' are, of course, only a rough approximation of the possible cost. For example, extra-capacity could be overstated if only 'normally available' capacities are to be considered. Similarly, *all* in-process inventories cannot be avoided in an on-going operation regardless of how little margin is to be provided. Furthermore, the determinations of the replacement costs of equipment or inventories is highly approximate and might deviate from the values used.

Several observations can, nevertheless, be made. It appears that the costs of carrying inventories substantially exceeds that of providing extra-capacity. Additionally, while the total initial investment in the 'margin of safety' is substantial, of the order of $62.3 million, the annualized costs are much more modest in the range say of $5.03 million.

With regard to economic benefits, namely the avoidance of mill production stoppages, we can apply the equation (2.3) developed previously to obtain the results shown in the lower portion of Exhibit 3.4. These results are based on the Gross Revenues, Operating Income and Mining Costs reported in 1979 and hence would be larger if 1980 values were to be used. They indicate the magnitude of the benefits of avoiding mill output stoppages of varying durations. Clearly if, in the absence of the 'margin of safety' only a single day of mill shutdown occurs due to lack of feed then the cost of the extra-capacity and inventories cannot be justified on these simple economics alone. However, if more than 6.9 days should occur, the 'margin of safety' would be fully paid by savings in avoided lost production based on Gross Revenues. More importantly, any major mine disruption which, in the absence of the 'margin of safety', leads to a major stoppage of say 30 or 60 days would result in an economic loss far exceeding the cost of providing a margin.

The final step in determining the economic desirability of providing the 'margin of safety' depends on the assessment of the probabilities of different days of stoppages and the risk attitudes which the operation wishes to adopt. The sample operation described has, with its given 'margin of safety',

avoided any mill stoppages over a 15 year period. However, a history of stoppages of various durations in the *absence* of the 'margin of safety' is obviously unavailable. Stoppage-free operations might have been achievable with lower margins of capacity or inventories, but with higher levels of stress and uncertainty. However, a single major mishap over the past incurred due to a lack of margin, could have resulted in losses exceeding all past annual costs.

An organization, in effect, is paying a form of insurance against mill stoppage. A desire for predictability and smoothness of earnings may dictate that a premium, in excess of the expected costs, be paid. This premium is the annual costs of 'a margin of safety' which guarantees against the unlikely event of a 30 day or longer mill stoppage. Such a major stoppage could even jeopardize the financial stability of the entire mine in the year of occurrence. There would then be some economic value in paying a known annual premium against the possibility of a single major disruption in the cash flow of the mine.

4. Applicability of the 'margin of safety' to other mining operations

Each existing or potential mine in Ontario is unique and faces a different set of economic parameters. In particular, mines will vary in the size and quality of the ore-body, in their life-cycle stage, in the structure of their ore-body and mining methods, in the age and technology of their equipment and in the financial strength of the operation. Each of these considerations can affect the mine's perception of the economic costs and benefits of providing a 'margin of safety'.

Before individual consideration of the above factors, an overriding issue must first be recognized. If a mine is of marginal profitability, survival rather than long-run profitability is likely to dominate the decision process. Under such circumstances current cash-flow will tend to dictate capacity or inventory decisions, regardless of the longer-term economic trade-offs involved. The option of ceasing all operations becomes more relevant and investments repayable only over a longer-term are suspect. Financial risks, unacceptable to a more profitable operation, may be taken in an attempt to continue operations of the mine. Discretionary investments, for whatever purposes, generally will be postponed.

Such operations, however, would constitute an extreme and most operating or proposed mining operations would, most likely fall somewhere above a minimum level of profitability. Nevertheless, it is instructive to explore how variations in the situation of a specific mine may alter the economic trade-offs defined in Section 3 for our sample mine.

First, let us consider the impact of the size and quality of the ore-body remaining. The prime impact of ore quality will be reflected in the revenues or contributions per ton which can be realized. Thus the penalty of mill shutdowns will vary with ore quality. For example, if our sample mine were operating at the 1976 Ontario average gross revenues of approximately $46 per ton, then the potential benefits from avoidance of a day of mill shutdown would be reduced from $0.73 million to $0.456 million. Furthermore, if in addition, mining costs were $26 per ton, then the contribution lost per day would be reduced to $0.196 million on the same scale of operations. Obviously, the potential benefits of a 'margin of safety' are substantially reduced for a lower quality ore-body.

With regard to size of the remaining ore-body, the economic parameters are altered in two ways. First of all, mining costs per ton are likely to be higher as in the above case. Secondly, the remaining lifetime of the mine depends on the relationship of the remaining reserves and the size of the mill. If only a short lifetime is remaining, either due to a small initial ore-body or to depletion of a large one, the cost of extra-capacity rises substantially. For example, suppose that our sample mine had sufficient reserves to assure only 5 more years of production, the annualized costs of Exhibit 3.4 would then become $2.43 million rather than $1.24 million as the capacity investment would need to be amortized over the much shorter period.

A common problem in marginally profitable mines is the uncertainty of how many years of mineable reserves are in fact remaining. Fluctuations in metal prices cause the size of economic reserves to vary. At one price a mine may consider itself as having only a year or two of ore reserves and any capacity investments would have to be amortized over such a period. If prices rise, the life of the mine may again be extended as marginal ore becomes economic and the mine may continue operations. Under such conditions of uncertainty, the investment in extra equipment or facilities might need to be amortized over a single year, raising the effective annual cost to as high as $9.40 million from $1.24 million. Clearly the cost of the 'margin of safety' to such a mine will be significantly increased, possibly even rendering the entire operation uneconomic.

A further effect of a short remaining lifetime of a mine is the reduction which it creates in the potential benefits of mill-shutdown avoidance. This is a result of the fact that the delay in the realization of profits on a ton of ore is substantially reduced. If a mill will need to be shut down in the near future due to exhaustion of mineable ore, the ton of foregone current production will extend the mill's life and thus be recovered with a relatively

short time delay. Thus, for example, if our sample mine had only 5 years of remaining ore, then the recovery of lost profits would occur in 5 rather than 30 years reducing the penalty per ton of mill shutdown by \$13.32 (= \$26.8/(1.15)^5) from the previous reduction of \$0.40 per ton. The reduced daily cost of mill shutdowns would become \$0.60 million in gross revenue or \$0.49 million in contributions.

The stage of a mine's life-cycle is also critical to the computations of the costs or benefits from a 'margin of safety'. Suppose that at the early stages of the exploitation of an ore-body, mill capacity and mine capacity are balanced with an economic provision for a 'margin of safety' in the mine production. As the ore-body approaches total depletion, however, the production capacity of the mine will almost certainly fall. This leaves the mine in a situation in which the mill's capacity may exceed the capacity of the mine. Under such circumstances, any unutilized mine capacity leads to a loss in product output. Avoidance of the penalties of lost mill production would require maximum mine production. A margin of safety could then be provided only by processing ores from other nearby ore-bodies, if available, or by specifically reducing the target mill production below its economic maximum.

The provision of in-process inventories to provide a 'margin of safety' may be affected by the nature of the ore-body and the mining method emphasized. The sample mine considered uses a mining technique based on the blasting of large stopes. This method is available only if the ore-body is of a structure permitting large blasts. It naturally results in the carrying, on average, of larger in-process inventories than in a mine in which the ore-body contains only smaller pockets of mineable ore. Furthermore, storage space must be available for both underground and on surface inventories of ore, and such may not be readily available in some mines. With mines using a more continuous drilling, blasting and hauling sequence, the provision of in-process inventories may require larger handling and storage costs. In particular, the lack of an available surface pit, for example, may result in the oxidization of a surface stockpile of ore making a surface inventory of ore prohibitively expensive in effective 'handling' costs.

While the design of new mining operations permits a broad choice of mine-mill capacity relationships, the existing mine finds itself partially locked into the equipment and facilities originally developed. While the capacities of some of the processes are relatively flexible, others cannot be readily altered. For example, additional drilling units or LHD units can be acquired. However, the hoisting capacity may be increased only with a major investment or possibly complete replacement of the existing facility. Since

the mine capacity is ultimately determined by its weakest link, the addition of capacity to the non-critical processes may not contribute significantly to reducing the amount of mill stoppage. The linearity of developing extra-capacity assumed in Exhibit 3.2 may well be violated.

A similar cost differential arises in the valuation of the in-process ore inventories. If the mining costs of a mine are substantially higher than the approximate $11.36 per ton assumed in our sample mine, then the costs of carrying inventories will be correspondingly higher. For example, suppose that a mine with a poor ore-body structure has a basically 50% higher mining costs. This would then lead to an annual inventory carrying cost of $7.55 million as compared to the $5.03 million of Exhibit 3.4 due to a higher value of $81.25 million on the inventories carried. Of course, the number of days of inventories carried might be reduced without necessarily implying that *no* margin should be provided through inventories.

As a final consideration, let us consider the perceived costs and benefits from the perspective of an operation in a weak financial position. While a weak position would most likely be due to many of the operating characteristics being significantly poorer than in our sample mine, let us consider the pure financial effect. Being in a weak financial position generally means that capital is scarce within the firm and furthermore that it is not readily available from bonds or bond borrowings. If additional capital is available, it would most likely be in the form of additional equity capital which is willing to accept the risks of a financially marginal firm. Under those assumptions, the effective cost of capital to the mine may rise from 15% to possibly even 25% in today's inflationary equity market. Such a cost of capital would increase the annualized cost of the extra equipment to a level of $2.04 million from the $1.24 million shown in Exhibit 3.4. Simultaneously, the costs of carrying in-process inventories rises to a level of $9.21 million from the $3.79 million shown in Exhibit 3.4. The potential benefits of Exhibit 3.4, however, are not substantially altered by this increased capital cost. Consequently, the costs of providing the given 'margin of safety' are greatly increased without any significant increase in the benefits.

As a final observation, a combination of the factors considered above could occur in any given specific mine. If this is the case, the cost-benefit tradeoffs of a 'margin of safety' would be quite different than that presented for our sample mine. On the other hand, some operations may, in fact, find that the trade-off is more favourable, or not much less disadvantageous.

5. Conclusions

The 'margin of safety' concept can be considered from the perspective of the economic trade-off which it implies. Based on a consideration of only the principal effects, an economic justification of the maintenance of a 'margin of safety' clearly will vary with the characteristics of the mine in question. Under the proper circumstances, it can be seen that the 'margin of safety' can be justified simply from the perspective of an insurance premium against mill stoppages. Under alternative circumstances, the costs payable may exceed the potential economic benefits and the provision of a 'margin of safety' would need to be justified on other considerations.

In this report, only directly tangible economic benefits have been considered in keeping with the limited scope of this study. It is obvious that the availability of a 'margin of safety' may contribute indirectly in other areas of management concerns. For example, labour relations may be enhanced in operations with an available margin thus possibly reducing turnover or increasing the productivity of the workforce. This would reduce labour costs contributing to profitability.

More importantly, with regard to the main concerns of the Inquiry, the 'margin of safety' is credited, by the practising operation, as a contributor to the excellent safety record achieved. It appears that while other factors, such as training, work-rules, work attitudes or compensation schemes may be found to be more important, the reduction of pressures required to achieve the needed quota of production created by a 'margin of safety' must be considered as an additional possible tool in accident prevention. The achievement of excellence in safety appears to be possible even in operations which do not have this margin. It must be recognized that, for some mines, the imposition of this concept may impose economic penalties which are not only large but in fact may lead to unprofitability and ultimate closure. Many mining operations may, however, find that a 'margin of safety' provides an economical approach towards improving their safety record.

Exhibit 2.1

Mine schematic

Steps in process	Equipment/ facilities required	Ore inventories or reserves
1. Development drilling 2. Stope drilling 3. Blasting of ore	Drilling units Mining levels & headings	Developed ore regions Drilled ore stopes Broken ore
4. Hauling of Muck	LHD units Ore passes	Coarse ore bins
5. Primary crushing	Underground crusher	Fine ore bins
6. Hoisting of ore	Hoists Power generators	Surface load out bins Surface stockpile
7. Transporting ore to mill	Hopper cars Engines	Railroad bins
8. Secondary crusher	Mill crusher	Mill fine ore bins

Exhibit 2.2

Components of revenues

Gross operating revenues =

Labour Costs + Material Costs	Operating costs
+ Depreciation + Administrative Costs	Overhead costs
+ Interest Payments + Corporate Profits before Taxes	Returns on capital

Exhibit 3.1

Capacities in mining process (Tons per week)

Mining equipment/ facilities investment	Peak short-term capacity	=	Generally available capacity	+	Unscheduled downtime	+	Maintenance downtime	+	Third shift or spare capacity	+	Weekend capacity
Drilling Units (18 Jumbo Units @ $94,000) = $1,692,000	210,047 (18 units × 24 hrs × 7 days × 69.46 tph)		72,516 (9 units × 116 hrs × 69.46 tph)		2,500 (9 units × 4 hrs × 69.46 tph)		41,675 (5 units × 24 hrs × 5 days × 69.46 tph)		33,341 (4 units × 24 hrs × 5 days × 69.46 tph)		60,014 (18 unit × 24 hrs × 2 days × 69.46 tph)
LHD Units (15 Units @ $140,000) = $2,100,000	175,039 (15 units × 24 hrs × 7 days × 69.46 tph)		72,516 (9 units × 116 hrs × 69.46 tph)		2,500 (9 units × 4 hrs × 69.46 tph)		50,011 (6 units × 24 hrs × 5 days × 69.46 tph)		—		50,011 (15 units × 24 hrs × 2 days × 69.46 tph)
Orepasses (6 systems @ $549,000) = $3,294,000	315,000 (6 systems × 24 hrs × 7 days × 312.5 tph)		73,312 (2 systems × 117.2 hrs × 312.5 tph)		1,688 (2 systems × 2.7 hrs × 312.5 tph)		—		150,000 (4 systems × 24 hrs × 5 days × 312.5 tph)		90,000 (6 systems × 24 hrs × 2 days × 312.5 tph)
Primary Underground Crusher (1 Unit @ $1,852,000) = $2,852,000	235,000 (24 hrs × 7 days × 1,400 tph)		96,320 (16 hrs × 5 days .14 avail. × 1,400 tph)		15,680 (4 hrs × 5 days .14 avail. × 1,400 tph)		28,000 (4 hrs × 5 days × 1,400 tph)		28,000 (4 hrs × 5 days × 1,400 tph)		67,200 (24 hrs × 2 days × 1,400 tph)
Hoisting (2 skip hoists) = $6,240,000	151,200 (2 units × 24 hrs × 5 days × 450 tph)		70,704 (2 units × 16 hrs × 5 days × .018 avail. × 450 tph)		1,296 (2 units × 16 hrs × 5 days × .018 avail. × 450 tph)		18,000 (2 units × 4 hrs × 5 days × 450 tph)		18,000 (2 units × 4 hrs × 5 days × 450 tph)		43,200 (2 units × 24 hrs × 2 days × 450 tph)
Transportation (3 Locomotives @ $200,000) = $600,000	157,500 (3 units × 24 hrs × 7 days × 312.5 tph)		70,000 (2 units × 16 hrs × 7 days × 312.5 tph)		—		34,944 (2 units × 8 hrs × 7 days × 312 tph)		52,500 (1 unit × 24 hrs × 7 days × 312 tph)		—
Mill-Feed Required			70,000 (24 hrs × 7 days × 416.2 tph)								

Exhibit 3.2

Extra capacity margins

	Weekly extra capacity	% of peak capacity	Annual days of mill requirements	Investment required
	(tons)		(days)	($)
Drilling units:				
Total	95,871	45.6%	498	$ 771,552
General availability	2,516	1.2%	13	20,304
LHD units:				
Total	52,527	30.0%	273	630,000
General availability	2,516	1.4%	13	29,400
Ore passes:				
Total	243,312	77.2%	1,265	2,542,968
General availability	3,312	1.1%	17	36,234
Primary crusher:				
Total	121,520	51.7%	631	1,474,484
General availability	26,320	11.2%	136	319,424
Hoisting:				
Total	61,904	40.9%	322	2,552,160
General availability	704	0.5%	3	31,200
Transportation:				
Total	52,500	33.3%	273	199,000
General availability	0	0%		0
		Mine totals:		
			Total	$8,170,164
			General availability	$ 436,562

Exhibit 3.3

In-process inventories (tons)

Inventory	Target	3 yr. average	3 yr. range	Actual average value
Developed ore region	3,3640,000 (364 days)	2,730,000 (273 days)	NA	$4,598,025 (@ $1.68/ton)
Drilled ore stopes	3,640,000 (364 days)	3,198,583 320 days	(280-520 days)	22,102,208 (@ $6.91/ton)
Broken ore	3,640,000 (364 days)	1,610,434 (161 days)	(104-209 days)	11,530,707 (@ $7.16/ton)
Coarse ore bins	20,736 (2 days)	NA	NA	149,092 (@ $7.19/ton)
Fine ore bins	16,964 (1.6 days)	NA	NA	121,971 (@ $7.19/ton)
Surface load out bins	10,000 (1.0 days)	NA	NA	113,600 (@ $11.36/ton)
Surface stockpile	30,000 (30 days)	1,342,106 (134 days)	NA	15,246,324 (@ $11.36/ton)
Railroad bins	3,333 (1/3 day)	NA	NA	37,862 (@ $11.36/ton)
Mill fine ore bins	24,000 (2.4 days)	NA	NA*	272,640 (@ $11.36/ton)

*No unplanned mill stoppages in 15 years.

Exhibit 3.4

Costs/benefits of maintaining a margin of safety

		Annual Costs
Extra equipment/facilities:		
$(\$8{,}170{,}164) \times (.15) \times \dfrac{1}{1 - \left(\dfrac{1}{1.15}\right)^{30}}$	=	\$1.24 million
Inventory carrying cost: $(\$54{,}172{,}429) \times (.15 + .02 - .10)$	=	\$3.79 million
Total annualized cost		\$5.03 million

Potential benefits*

			Gross Revenue $73.6/ton (Mill $)	Contribution $62.24/ton (Mill $)
	R =			
Avoidance of mill shutdown for:				
1 day	$1 \times 10{,}000 \times (R - \$26.8/(1.15)^{30})$	=	\$ 0.73	0.62
5 days	$5 \times$	=	3.65	3.09
10 days	$10 \times$	=	7.32	6.18
30 days	$30 \times$	=	21.95	18.55
60 days	$60 \times$	=	43.91	37.10

*Based on 1979 year-end values.

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A paper on the relationship between alcohol and drugs, and accidents in the workplace

October, 1980

The Commission requested Mr. Martin Shain, M.A. Dip. Crim., Head, Employee Assistance Program Research, Addiction Research Foundation of Ontario to prepare a paper on the relationship, if any, between alcohol and drugs, and accidents in the workplace. Mr. Shain is author of a number of publications and is senior author of *Employee Assistance Programmes – Philosophy Theory and Practice*, Lexington Books, D.C. Heath and Co., 1980.

Abstract

The relationship between alcohol, drugs and accidents in the workplace is explored in the context of available evidence, the balance of which suggests that the contribution of substance abuse and misuse to personal injury and property damage losses has been underestimated. Recommendations are made with specific reference to the Mining Industry which require that a data base be developed for this sector of the economy in Ontario. Necessary steps are seen as: (1) Conducting independent prevalence surveys of alcohol and drug use in specific mining organizations; (2) Relating this information to safety-related behaviour as monitored through, (a) observation and interviews and (b) searches of official records, in particular, WCB files. Collaboration from the outset with key interest groups such as the Mines Accident Prevention Association, unions, concerned health and safety agencies, as well as management is recommended as the prerequisite to the effective implementation of such a research program and its results.

Alcohol, drugs and accidents: the general relationships

The claim that alcohol consumption and accidents are related has an intuitive appeal which is supported by evidence of varying types and quality. In the workplace, the prohibition against the use of alcohol on the job or during work hours (including lunch and coffee breaks) is common. In certain industries, such as those concerned with transportation and with dangerous extraction or manufacturing processes, the rule tends to be stated in quite unequivocal terms even though its enforcement may be subject to a surprising amount of variation. The rule is often extended to cover the use of any intoxicants so that drug use is similarly prohibited. It is unclear whether this rule would be applied equally to the prescribed use of drugs and to the illicit use of drugs. The former are just as likely to result in safety problems as the latter if they are taken at a rate that exceeds the prescription level and occasionally are dangerous to use even at prescription levels.

In the transportation industry–particularly in the case of railways, haulage and air travel–the rule against the use of intoxicants is extended to those who, though not on duty, are 'subject to duty'; i.e. they could be summoned to work if need be. In the case of airline pilots this rule extends to a minimum of 24 hours before any flying duty. Such a rule is based on research of the type conducted by Ryback and Dowd (1970) in which it was shown that even 34 hours after ingestion of alcohol, professional pilots still manifested performance relevant deficits in their reactions.

Most of the widely cited research on alcohol and safety has been conducted in relation to known or suspected alcoholics (*Levens*, 1976). These studies tend to be dramatic in their findings leading to the now popular assertion that alcoholics have anywhere between two and three times the accident rate of other employees (*Pell* and *D'Alonzo*, 1970, 1973; *Maxwell*, 1959). These are respectable studies, but unfortunately they do not go far enough. For example, they deal only with 'alcoholics'. We do not know on what criterion or criteria this designation was applied. It is *likely* that it applies to people whose alcohol consumption was in some way conspicuous since it is well established that the identification of alcoholics by supervisors and managers occurs in considerably fewer cases than the condition itself (*Shain and Groeneveld*, Ch. 2, 1980). Further, the safety risks represented by alcoholics and other excessive drinkers will vary from industry to industry and even within industries since the management of work environments is a highly variable phenomenon. Consequently, it may be more difficult for an alcoholic to hurt himself or herself in some work environments than others. One should not, therefore, expect the relationship between alcohol and accidents to be a constant.

A good case exists for extending the scope of this enquiry to deal with not only rank alcoholism but also acute episodes of drinking and sustained heavy drinking which may not even manifest itself in the form of intoxication. Wolkenberg, *et al* (1975) demonstrated the delayed effects of acute alcohol intoxication on job performance in a laboratory situation. Eye-hand coordination, reaction time and other motor-sensory functions were found to be impaired on the morning and afternoon following the previous evening's ingestion of alcohol. The investigators were in fact looking at the effects of hangovers, an aspect of drinking which also seized the attention of Mannello, *et al.* in a study of railroad employees in seven companies in the United States (1979). Here, it was found that 20% of employees 'subject to call' came into work hung over, in addition to another 15% who came in 'a little drunk' and 5% who were 'very drunk'. It may be said, then, that Wolkenberg's findings are of more than academic interest. It is important to note, with Wolkenberg, that the *type* of accident which may occur varies with the amount of alcohol consumed. At low blood alcohol concentration (BAC) levels it was found that subjects tended to overcompensate for not feeling their best by trying harder on some performance tests. In some cases they were successful but in others their overcompensation resulted in trying too hard–for example in lifting a weighted object–suggesting that in a real situation this behaviour could contribute to a *backward* fall. In the case of high BACs one observed that not only were subjects less able to perform on sensory motor tests but also that they exhibited gross motor deficits which could contribute to a *forward* fall. It is important to remember that these are the after-effects of intoxication,

not of intoxication itself, at least in its recognizable form. As Wolkenberg points out, safety control relies upon the ability of workers to predict how their own bodies, and those of their fellows, will respond in given situations. Take away that predictability and potentially hazardous situations arise. However, it is essential to note that the amount of alcohol consumed is not a constant risk factor. The consequences for safety of a given level of consumption will vary a great deal depending on characteristics of the individual, characteristics of the job and characteristics of the physical and social environment in which the job is done.

Even when attention is limited to people designated as alcoholics we find that their safety related performance varies over time even in the same environment. Borthwick (1977) was able to show that among enlisted Navy personnel the personal injury accident records of the majority of referred alcohol cases became *better than normal* one or two years prior to their actually being sent for treatment. This may have been a response to warnings and other disciplinary measures introduced at this time. However, a subgroup of enlisted men–about 20%–reacted during this same period by having a spectacularly higher number of accidents than the norm. This phenomenon is probably related to the operation of an axiom of Loss Control Management called 'The Principle of the Critical Few' (*Bird and Loftus*, 1976). This principle states that it is usually a disproportionately small group who are responsible for the majority of losses incurred. This phenomenon has been noted in the case of absenteeism by alcoholics (*Pell and D'Alonzo*, 1970) where over half of them had reasonably good attendance records. It was a subgroup of people with dramatically high absence rates who elevated the norm for the whole group. Trice (1962) observed that members of Alcoholics Anonymous had less accidents than would have been expected during the time before their referral for treatment. One self-reported set of reasons given was that alcoholics are very careful to avoid detection and tend to be very safety conscious while it is still within their power to be so. When an alcoholic believes he cannot function safely he may well absent himself rather than go to work and have an accident.

In the case of employees who, even though they may be at home, are 'subject to duty', this self-protective behaviour may not apply since to refuse a call may mean disciplinary action. The phenomenon noted by Mannello (ibid) in the railway study may, therefore, be partly attributable to this constraint. Intoxication rates, and the percentage of workers who drink while on duty varied enormously from one company to another in the railroad study. The following table illustrates this point with reference to the two extreme cases.

	Railroad C	Railroad F
Percent drinkers	55	84
Percent workers who get drunk at least once annually	50	77
Percent workers who drink on duty	6	24
Percent workers who "cover up"	5	18
Percent workers who favour automatic dismissal for drinking rule violation	50	15

Source, Fig. 10, pg. 20, Mannello, 1979.

Mannello suggests in effect that the conditions in company 'C' are part of an interdependent system where strict rule enforcement is effective in a cultural environment which endorses moderate personal drinking standards.

In this same study, 19% of all railroad employees were determined to be problem drinkers. Mannello's definition of 'problem drinker' (pg. 54) is "a repetitive excessive drinker whose use of alcoholic beverages is regularly and directly linked to private or public harm and is seen as the source of difficulties in one or more important aspects of his life. The category includes the alcoholic." This definition is broader than some but nonetheless it is strict enough that 19% is a very high proportion of the population to fall within it. Recent estimates in the public and private sectors of the workplace in Ontario classify between 1.9% and 2.8% of the sampled organization's employees as being in a very high risk category with regard to alcoholism while between 8.7% and 14.8% are in a moderately high risk category (*Shain and Groeneveld*, Ch. 7, 1980). Note that in the Ontario surveys people are assigned to risk categories rather than declared to be alcoholics or not in a definitive manner. The Ontario surveys deal in probabilities, not certainties. Even so, we have to add both risk categories to make the Ontario figures come out anything like the railroad figures. We might operate on the working assumption, then, that Mannello is using a definition of problem drinker which incorporates roughly 3% clear-cut alcoholics and about 16% excessive drinkers whose pattern of consumption is regularly associated with private or public harm.

It comes as a surprise, therefore, to learn that only 4% or 1200 or the 30,000 compensable injuries which occurred in the railroads in one calendar year were attributed to alcohol. Mannello translates this into dollars by simply computing 4% of $12.5M, or $500,000–the proportion of personal injury compensations attributable to alcohol. There are two reasons to doubt the accuracy of this figure. Both involve our attempting to arrive at the probable number of alcohol related accidents by means other than

employee estimates, which was Mannello's method. First, we might apply to the railroad case the 'formula' which says that alcoholics have approximately 3 times the number of accidents that other 'normal' employees have. We have seen the problems associated with the use of this statistic, but it may serve here as a rough yardstick against which to assess the employee report method. Let us say that a modest 3% of the workforce can be classified as alcoholics. Applied to the 7 railroads this means 6,999 employees. The average compensable personal injury accident rate for all 233,300 employees was 0.13 per annum. For alcoholics, then, this rate would be 0.13×3, or 0.39. According to this, the 6,999 alcoholic employees should have had 2,729 accidents, or 9% of the total. If the costs are simply pro-rated, their contribution is $1,125,000. Again, this assumes that the average *severity* of alcohol-related accidents is the same as the average severity of all other accidents combined–an assumption that currently cannot be proved or disproved.[1] This figure, of course, does not allow for the costs generated by the 16% who are also problem drinkers according to Mannello. It seems, then, that according to this method of estimation, Mannello's figures are much too low.

A second method of estimation is based on a ratio which is believed to hold between the rate of serious, disabling injuries and other classes of injury and property damage (*Bird and Loftus*, 1976). According to this proposition, which has been validated in an impressive number of instances, one serious accident occurs for every 10 minor but reportable injuries and for every 30 property damage accidents of all kinds. If this is the case, we should be able to predict the probable number of serious injuries from a knowledge of the number of property damage accidents and vice versa. In the case of the railroad study, we have no direct information on the rate of property damage accidents attributable to alcohol, but we do have 44,000 reportedly observed incidents of alcohol-related damage. Let us assume to begin with that these were 44,000 *separate* incidents; i.e. one incident was not reported by multiple observers. According to the ratio just outlined, one should therefore have expected to see $\frac{44{,}000}{30}$ serious injuries, or 1,333 due to alcohol abuse. In addition, one should have seen $1{,}333 \times 10$ or 13,330 minor but reportable injuries attributable to alcohol abuse. Together, these alcohol-related accidents would account

1. Mannello and Seaman (1979), in a fuller report, cite the testimony of a safety officer on one of the studied railroads who said that "four of six deaths that occurred on property during the seven years prior to the study were alcohol-related. His experience indicated that problem drinkers are more likely to be involved in serious accidents." (pg. 77)

for 48.8% of the total of 30,000, representing a cost of $6,125,000.[2] Because we have no way of knowing how many of the 44,000 incidents of alcohol-related property damage were reported more than once it is impossible to know by what factor we should divide that cost in order to arrive at a reasonable figure. However, in order to arrive at anything close to Mannello's estimate, we have to divide by a factor of more than 10, which taxes the credibility of the latter estimate even more. In short, we have reason to question the figures presented by Mannello with regard to the involvement of alcohol in accidents. There is good reason to believe that alcohol was involved in a minimum of 9% of all injuries and that the figure was probably much higher, particularly if the role of problem drinking as opposed to rank alcoholism in accidents is recognized. In fact, Mannello and Seaman (1979) report elsewhere that in the railroads studied ''there is strong experiential evidence of at least some safety and medical officers that far more accidents involving injuries are alcohol-related than are reported''.

Mannello reports that a very small fraction of drinking rule violations are actually reported–only 900 out of 174,000 thought to have occurred in one year. A much higher proportion–80,000 out of 174,000–are reportedly observed. Thus, the reporting rate is 0.5% as opposed to the observation rate of 45.9%. About one in three violators is dismissed. Nonetheless, one of the factors most influential in discouraging reporting is apparently the fear that an employee might be dismissed even for a first offense. This lack of predictability in relation to the consequences of reporting a violation tends to consolidate the already powerful peer norms around not 'squealing'. Mannello points to a railroad company in which rule violators were *consistently* offered counselling and treatment for their drinking problems. He notes that this company had the highest rate of reported and charged violators and, presumably as a result, it had also one of the lowest rates of on-duty drinking and intoxication.

Mannello concludes that the relationship between alcohol and accidents is ''not being adequately investigated'' in spite of a widespread concern about it among all levels of employees.

The relationship between drug use or abuse and industrial accidents is, to this writer's knowledge, the subject of much more anecdotal evidence than is the case with alcohol. In the first place, it is difficult to obtain

2. Outlandish though such an estimate may seem, based as it is on overlapping reports of damage to property, it is of interest to note that in Mannello and Seamans' major report, a safety officer on a railroad not actually studied claimed that ''fully 50 per cent of all accidents on that railroad are directly or indirectly related to employees' drinking'' (pg. 77).

reliable estimates of the prevalence of drug use in industry. In the surveys of Ontario industries reported by *Shain and Groeneveld* (Ch. 4, 1980) employers were often unable to give estimates of the extent of drug use. The size of the employer groups who could not provide estimates ranged from 26% in one community to 70% in another. In one case 20% of all employers estimated that 1-5% of their workforces abused drugs to the point at which it affected their job performance while in another case only 5% placed the population at risk in that range. In one informal study conducted by the author at a metal fabricating plant in Toronto it was learned that as many drug users were known to the Head of Personnel as were problem drinkers. The known drug users in this case were 1.7% of the workforce. They were users of all sorts of chemicals, were young, kept themselves apart from most other employees and were considered safety hazards.

It appears that in Toronto at least, the police are being asked to investigate cases of drug dealing and abuse in industrial settings. In a telephone interview with a policeman who has worked undercover for 6 years in the drug area it was learned that drug use on the shop floor is becoming increasingly accepted and acceptable. This officer had been partly responsible for the recent arrests of a drug ring in the Post Office and as such had worked alongside users and traffickers as a fellow employee for months. He observes that detection of drug use by supervisors, particularly by those past their late thirties, is very low. Users can feign normalcy in front of supervisors and the ability to do this is a matter of pride, status and amusement among younger employees. Even older workers (those over 40) are seen to use drugs–for example, codeine-based substances dissolved in coffee. Cannabis, LSD and methamphetamine are apparently the more common drugs but heroin and cocaine are not unknown in the workplace. Boredom and alienation are frequently cited as the reasons for use of these substances where work is repetitive, monotonous, hot or noisy. Since supervisors may not recognize the drug user it is likely that accidents involving their use are similarly undetected in many instances. In a typical referral pattern through an Employee Assistance Program one might see 10-15% of all cases attributed to drug use, yet this is almost certainly not a valid reflection of its prevalence in industry.

Obtaining a more accurate data base

In spite of the questions raised about Mannello's study of the seven railroads, it is nonetheless a valuable piece of work which unfortunately demonstrates the relative paucity of information about the role of alcohol and drugs in accidents. If Mannello's study is representative of the kinds of estimates which are typically made about the contribution of substance abuse or misuse to accidents we might conclude that a significant proportion of it is

not being picked up through the devices normally used for monitoring the causes of accidents. In Ontario, and in Canada generally, one might expect the same problem to arise since we rely on similar types of evidence. One principal record-keeping device is the accident report which supposedly *must* be filed with the Workmen's Compensation Board when accidents of certain types occur. Although there are occasionally questions about the conscientiousness with which accident reports are filed, a more important question from our present point of view is the *completeness* of the information contained in the file. There is reason to doubt that a search of such material would be very fruitful given the scepticism of many in the field about the current level of information contained in these files (*Ellis*, 1975). However, the *potential* for greater completeness remains. In an interview with the personnel director of a manufacturing firm employing 400 people in Toronto the respondent explained to the present writer how accidents are typically reported in terms of *what* happened as opposed by *why*. The term 'carelessness' in reference to the accident victim is often found, but if this term is explored one frequently uncovers a chain of circumstances leading up to the reported accident which often tends to change the complexion of the event. In particular, it tends to spread the responsibility for the accident over a larger number of people and may bring into question various aspects of supervision, management or administration. This more thorough type of enquiry is consistent with the principles of Loss Control Management (*Bird and Loftus*, ibid). Unfortunately, thorough investigations of this type tend to be conducted only in cases of very serious or fatal injuries. It is clear that they have the potential for uncovering any involvement of alcohol or drugs in the chain of events leading to the reported accident. However, the absence of detail on WCB reports may not be entirely due to indifference with regard to the importance of the information. In the case of accidents in which alcohol or drugs have been involved at some point in the causal chain there may be an unwillingness to disclose this fact for fear of repercussions such as grievances or lawsuits on the part of the victim or someone involved in the incident.

A first step in rectifying this situation involves engaging the interest of the WCB and safety associations in the accuracy with which such records are kept. A useful line of advance in this regard would be to conduct an independent survey of the relationship between alcohol, drugs and accidents in specific organizations and compare these results with those obtained from an analysis of WCB files submitted by the same organizations. Clearly, this would involve the willing cooperation of the organizations in question. It is equally clear–to this writer at least–that such a strategy is a necessary if not sufficient component in the attempt to better understand the role of substance abuse and misuse in accidents. Another approach

should involve case studies of the same specific organizations in which the comparisons just described are conducted. These studies should be of a sociological nature so that the normative influences of worker peer group dynamics could be observed as they interact with the structure and process of the work itself. This involves an analysis of the organization of work, including the division of labour, and systems of control and communication at both formal and informal levels. The general perspective which guides these recommendations is that of open-system theory which postulates the interdependence of social and technical aspects of the work environment (e.g. *Emery*, 1969; *Woodward*, 1970; *Perrow*, 1967). In this framework, the investigator or organizational consultant would see accidents, alcohol and drug use as events and behaviours which are inextricably linked with the more general functioning of the organizations in which they take place.

Current responses to alcohol and drug-related problems in the workplace

Although some employers still respond to the discovery of alcohol and drug related job performance problems by dismissing the employee in question there are a considerable number who apply some version of what might be called rehabilitative management in such cases (*Shain and Groeneveld*, 1980). The latter form of action includes the Employee Assistance Program in which the employee whose deteriorating job performance does not respond to 'normal' supervisory intervention is offered a choice between further disciplinary action or availing himself or herself of treatment services obtainable through the good offices of the employer. Obviously, such choices are constrained by the ultimate threat of job loss thus earning this intervention the euphemistic title of 'constructive coercion'. While these programs enjoy some success in restoring referred employees to former levels of job performance they are less successful in spotting troubled employees in the first place (*Shain and Groeneveld,* ibid). Nevertheless, it is becoming increasingly difficult in unionized settings for employers to discharge alcoholic employees who appear to represent a large proportion of those considered to be 'troubled'. Arbitrators have tended to take a dim view of employers who try to oust such employees without careful documentation of deteriorating job performance and warnings. There is apparently a growing tendency for arbitrators to reinstate alcoholic employees on the condition that they seek treatment (Appendix ''A'' in *Shain and Groeneveld,* ibid). Employee Assistance Programs (EAPs) therefore make good sense (or defense) for employers in their dealings with alcoholic employees.

The use of safety violations as an aspect or sign of deteriorating job performance might seem to be a natural device for supervisors to use in their activation of EAPs. To date, however, there is little evidence to suggest that this relationship is made at least in overt terms. It remains to be seen whether the passage of the Occupational Health and Safety of Workers Act, 1978 will eventually increase the degree to which 'unsafe behaviour' related to alcohol or drug abuse or misuse is used as a criterion for deteriorating job performance by supervisors in bringing EAPs to bear on employees. If the intent of the Act is to increase the protection of workers and if the duty to do this is seen to devolve as much on the employer as on the worker it is reasonable to hypothesize that employers would recognize the value of EAPs in achieving this objective. Mannello (*ibid*) noted that where such a treatment policy was consistently applied in the case of a railroad company the willingness to report incidents of *on duty* drinking was high. While we are dealing with more than on-duty drinking here, the same principle may apply to supervisors confronted with badly hung-over employees or workers who are still intoxicated from ingestion of alcohol or drugs out of work hours.

In an exploratory study of seven companies with EAPs in the Toronto area, it was learned that four of them had brought about joint membership of their safety committees and their EAP committees. This was done because of perceived connections between alcohol and safety (*Shain and MacDougall*, 1979). The present writer has received some encouragement from the Occupational Health and Safety Resource Centre at Queen's University, Kingston, to continue this line of enquiry. However, the importance of the issue probably warrants the attention of a well-resourced research project team to do justice to the subject. The importance of such enquiries is likely to increase as companies such as Canadian National Railways attempt to control on duty drinking by raising the expectation that line employees will report incidents of this type (*Appendix A*).* Here, as in Mannello's study, the relative clarity or ambiguity surrounding the perceived *consequences* of reporting such incidents for the reporter and for the reported will probably influence the success of this reformulated policy in a major way.

It is important to note that the Mining Industry in Ontario has taken an interest in EAPs beyond what might be expected. That is, although companies engaged in the extraction of minerals and oil represent only 0.3% of all work organizations in Ontario they represent 4% of all those organizations known to the Addiction Research Foundation as having Employee Assistance

*See page 146.

Programs or a related rehabilitative program. What is more noteworthy is the fact that among all those organizations known by ARF to be referring alcoholic employees for treatment at a rate of 1% or more (at least in 1977) mines accounted for over 13% of them. Within the mining industry, it appears that Metal Mines account for nearly 93% of the activity in the EAP area although they represent only 12.4% of all mines and services incidental to mining (*Shain and Groeneveld,* ibid, p. 58-61). Thus, although we do not have any clear idea about the prevalence of alcohol-related problems in the Mining Industry in Ontario, we may fairly deduce from the disproportionate interest shown in EAPs by this sector of the economy that such problems cause concern. It is also clear that some employers in this sector are forward-thinking enough to incorporate EAPs into their system of management.

Implications for the mining industry in Ontario

It is possible to generate estimates of the contribution of alcohol problems to accidents in the Mining Industry from a knowledge of the overall accident rate and a projected number of alcoholics in the workforce (*Appendix B*).* This requires, however, that we assume the prevalence of alcoholism and the constancy of the formula which says that problem drinkers account for 2 to 3 times the number of accidents that befall other workers. It further assumes that a line can be drawn between problem drinkers and non-problem drinkers, an assumption which cannot be validated. Rather than engage in this type of estimate, however, it may be more useful to develop a data base for the Mining Industry along the lines suggested in the body of this paper. This approach may be summarized as follows:

1) Studies of the prevalence of alcohol and drug related problems in specific industries should be conducted and an attempt made to match information about drinking and drug use with safety-related behaviour, including accidents. It is assumed that 'safety-related behaviour' is a broader concept than accidents since it would involve a study of typically unrecorded events such as 'near-miss' personal injury accidents and low-value property damage incidents. It will be useful to compare personal reports of accidents involving alcohol and drugs with official reports, in particular those filed with the WCB It should be noted that the matching of information about drinking, drug use and safety-related behaviour presents some difficult problems with regard to confidentiality. Particular attention would have to be paid to ensuring the anonymity of employees in relation to whom such potentially harmful information is collected. The alternative is to rely

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*See page 149.

on informant self-report of drinking and safety-related behaviour thus dispensing with the need for identification of respondents. Since both drinking, drug use and safety behaviour are in some ways influenced by the total socio-technical system of the workplace in which they occur, it is recommended that in conjunction with the type of study just outlined there be in-depth studies in which the actors are observed in their work environments. These recommendations are predicated on the hypothesis that the contribution of alcohol and drug problems to accidents of both the personal injury and property damage type is being underestimated, in some cases grossly.

It is worth noting that in most instances the role of alcohol and drugs in accidents in the workplace is discussed without specific reference to dose levels. That is, we are rarely told what *level* of intoxication was, or is typically, associated with accidents. This is evidently a complex question judging from a parallel but relevant literature on the relationship of alcohol and drug use to driving safety (*U.S. Department of Transportation*, 1980). In the case of driving, most provinces and states designate the level of alcohol concentration in the blood which will constitute legal impairment. In Ontario, for example, the limit is 0.08 mg per 100 ml. Regulations about driving while under the influence of various drugs are much more complex and hard to administer since most assessments of drug-related intoxication are based on 'invasive' blood tests. Even then there are few agreed upon standards for what constitutes legal impairment. In the industrial setting, however, even these rudimentary standards are absent. The introduction of random breath tests for the presence of alcohol would be simpler than random blood tests for drugs, but neither is likely to be readily acceptable to workers or unions. A stronger case can be made for such tests after accidents (particularly personal injuries) have occurred if circumstances and ethics permit. The absence of such data makes it difficult to understand the role of alcohol and drugs in accidents. It is recommended, therefore, that means be sought to convince managers, workers, union personnel and safety associations that testing for blood concentrations of alcohol and drugs be conducted in personal injury accident investigations.

2) Studies of the trends in the management of safety and in the management of alcohol and drug related problems should be made with particular emphasis on the actual and potential relationships between the two. This recommendation is based on the hypothesis that the two forms of management may either potentiate or frustrate one another and that common managerial and industrial relations factors may underlie the effective administration of both.

In order for such a program of research to be carried out effectively it will be necessary to engage the attention and interest of the WCB, the Mines Accident Prevention Association, relevant unions and hopefully the support of the Advisory Council on Occupational Health and Safety. Peripheral though potentially helpful advice might be sought from the Quality of Working Life Centre, the Canadian Centre for Occupational Health and Safety and other university-based health and safety centres such as the one at Queen's in Kingston. This is evidently an area in which politics and emotion play a role. Consequently, the utmost care must be taken in establishing credibility for the research and in engaging the active cooperation of all those interest parties who can be thought of as having a stake in the relationships between accidents, alcohol and drug problems and in doing something about them.

Appendix A

An example of company policy on alcohol and drug use in relation to safety, demonstrating the influence of the Occupational Health and Safety Act, 1979.

Canadian National Railway Company

Great Lakes Region

Memorandum of Agreement between the Canadian National Railway Company, the United Transportation Union and the Brotherhood of Locomotive Engineers.

IT IS AGREED THAT effective October 6, 1980, the Company and the Unions noted above will commence a pilot project on the Great Lakes Region on a trial basis for the period of one year for the purpose of exploring a new approach dealing with the administration of UCOR Rule 'G' in accordance with the following:

1. Employees suspected of having consumed alcohol or using drugs while subject to duty or while on duty will not be dismissed on the first occasion when such incident is reported by a fellow employee or employees.

2. If the incident involves detection of a violation of this nature when an employee is reporting for duty, he will be sent home without pay and will be required to report as soon as an interview can be mutually arranged between the local Company officer(s) and local Union accredited representative(s). In any case the employee will be interviewed within 48 hours from the time he is removed from service unless mutually agreed between the Company officer and local Union accredited representative.

   Note

   It is understood that provided the employee has not commenced work, i.e. reported for duty and is on pay, he will be afforded the same consideration whether or not such incident is reported by a fellow employee or company officer. Normal practice with respect to the administration of Rule 'G' insofar as company officers are concerned will apply in all other circumstances.

3. If the incident occurs while a road or yard service employee is *on duty*, the employee will be relieved of duty by the remaining members of the crew immediately the incident is observed and in the case of road service, if safety permits, the train will proceed to the next crew change point and the incident reported and arrangements for interview as above will be made.

4. If during the joint interview it is determined that the violation was caused by *poor judgment* only (i.e., no addiction problem) the employee will be counselled on the seriousness of his actions and warned in writing with a record retained on his personal file that a repeat offence will result in dismissal.

5. If, on the other hand, it is determined that the employee has an addiction problem, he will be afforded the terms and conditions contained in the company policy dealing with problem drinking and alcoholism and a record retained on his personal file. An employee who refuses the decision of the joint local union and local company officers who conducted the review shall have the right to refer his case to a duly recognized addiction specialist who he will authorize to make an assessment of his condition and provide a confidential report to the CN Medical Department. A copy of this report will be made available to the General Chairman and General Superintendent Transportation. If in the opinion of this addiction specialist it is revealed that the employee does *not* have a problem the provisions of Item No. 4 of this agreement

will apply. If it is confirmed that the employee has indeed an addiction problem, he will be afforded the terms and conditions of the company's policy. Failure on his part to take advantage of such opportunity could, after proper investigation of his case, result in his dismissal.

6. If, in the course of any Rule 'G' investigation it is determined that a fellow employee(s) was aware of the violation of the rule and did not report or take action on this knowledge, such employee(s) will also be subject to investigation and possible discipline.

7. The General Chairman may, after a period of not less than six months, make a recommendation to the General Superintendent proposing the reinstatement of an employee(s) who was discharged for violation of Rule 'G' when he believes there are special circumstances which warrant this action. Such cases will be thoroughly reviewed by the General Superintendent and the General Chairman will be advised of the position being taken by the Company within 30 days of receiving the General Chairman's recommendation. Any action taken by regional management will follow the procedure normally connected with the provisions of Mr. Latimer's letter dated October 12, 1976 dealing with reinstatement.

8. An employee counselled or warned as described previously or reinstated after discharge in accordance with Company policy and later found to have violated Rule 'G' again will be dismissed following investigation without benefit of any of the above procedures.

9. Employees governed by this Memorandum of Agreement will continue to retain their normal rights of appeal in the grievance procedure under their respective agreements.

It is understood and agreed that this pilot project will be subject to a review by the parties after a period of one year or at any time as mutually agreed.

This Memorandum of Agreement is subject to cancellation by any one of the signatory parties to the Agreement on 30 days' notice in writing to the other parties.

Signed at Montreal, Quebec, this 28th day of May 1980.

Appendix B

Estimate of alcoholics' contribution to the rate of personal injury accidents in Ontario's mining industry, 1980.

1. Annual frequency of personal injuries, prorated from 10 month data, 1980.	= 4,410 per annum
2. Number of relevant employees (above and below surface workers	= 34,675
3. Therefore, accident rates	= 0.127 per annum
4. Alcoholics are estimated to have, on the average, three times the rate of accidents of other employees. Therefore, alcoholics have 0.127 × 3 accidents p.a.	= 0.38
5. Assuming alcoholics are 3% of the workforce, there were 1040 alcoholics among the 34,675 employees.	
6. Therefore, alcoholics would have had 1040 × 0.38 accidents	= 395.20
7. Therefore, alcoholics, though only 3% of the workforce, accounted for 11.15% of the accidents.	
8. If 'excessive drinking' rather than 'alcoholism' were used as the measure, the contribution of drinking to accidents would almost certainly be much higher.	

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Statutory safety protection for uranium miners and mine plant workers

February 1981

The Commission retained Pierre Genest, Q.C., of the firm of Cassels, Brock to provide a legal opinion in respect to issues related to the administration of occupational health and safety laws at uranium mining and mining plants in the province of Ontario. Mr. Genest is an author of lectures on law of expropriation and a contributing editor, Holmested and Gale, Ontario Judicature Act, (Civil Procedure). He is a bencher of the Law Society of Upper Canada and was Special Advisor to the Federal government on Constitutional Negotiations, 1980.

Joint Federal - Provincial Inquiry
Commission into Safety in Mines
and Mining Plants in Ontario

434 University Avenue
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December 4, 1980

Pierre Genest, Esq., Q.C.
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Dear Sir:

Re: Statutory Safety Protection For Uranium Miners and Mine Plant Workers in Elliot Lake

An issue has arisen before the Inquiry with respect to the extent and validity of statutory safety protection for uranium miners and mine plant workers in Elliot Lake. The validity of federal control over all aspects of the atomic cycle, including uranium mining, is not disputed and, indeed, has been upheld by the Supreme Court (see Denison Mines Ltd v The Attorney-General of Canada (1973) 1 O.R. 797). The issue arises because of the desire of uranium miners and mine plant workers to be covered by provisions equivalent to the provisions of The Ontario Occupational Health and Safety Act, 1978 and the means used by the federal government to incorporate by reference the Ontario Act and regulations into the regulations under Part IV of the Canada Labour Code. The recent history and the events giving rise to the present situation are summarized in the attached brief submitted to the Inquiry by Labour Canada and in the attached staff memorandum to the members of the Select Committee on Ontario Hydro Affairs dated November 25, 1980.

The United Steelworkers and a number of miners have argued that the "exceptions" listed on page 4 of the Labour Canada Brief leave uranium miners in a disadvantaged position vis-a-vis other miners in this province. Whatever might be said of the merits of this argument, a much more serious difficulty, and one not alluded to in the Labour Canada Brief, has arisen. Professor John B. Laskin of the Faculty of Law, University of Toronto, was asked by the Counsel to the Select

- 2 -

Committee on Hydro Affairs his opinion as to whether the provisions of ss. 5 and 6 of the Statutory Instruments Act S.C. 1970 -71 -72 c.38, requiring the transmission of copies of regulations in both official languages to the Clerk of the Privy Council for registration, apply to The Occupational Health and Safety, Act, 1978, c.83 and the Regulations for Mines and Mining Plants O.Reg. 660/79 by virtue of their adoption by reference as the Canada Occupational Health and Safety Regulations for Uranium and Thorium Mines SOR /79-636 as amended SOR /80-409. In his opinion, which is also attached, he concluded that the transmission and registration requirements of ss. 5 and 6 of The Statutory Instruments Act do apply to The Occupational Health and Safety Act, 1978 and the Regulations for Mines and Mining Plants. These requirements were not met, thereby raising the question of the validity of the federal regulation and the extent of the statutory protection afforded to the Elliot Lake uranium miners in matters of conventional safety.

The Inquiry Commission is required to make recommendations to both the federal and provincial governments as to the adequacy of safety practices and arrangements in mines and mining plants located in Ontario. The adequacy of the statutory protection afforded to uranium miners in this province is an issue with which we must deal, and before formulating our recommendations, I would ask you to:

1) Review the "Laskin Opinion" and advise as to whether or not, in your opinion, reasonable grounds exist upon which to challenge the validity of the federal regulations.

2) If such grounds do exist, advise as to what steps must be taken to legitimize the regulation.

3) Review the December 1978 "Robinette Opinion" (attached and advise as to whether or not, in your opinion, reasonable grounds exist upon which to challenge the conclusions reached in that opinion; that is, the concurrent operation of the Ontario statute in respect of uranium miners and mine plant workers. The contrary "Ollivier Opinion" given by the Federal Department of Justice and dated October 13, 1978, is also attached.

4) If the concurrent operation of the provincial statute is beyond reasonable challenge,

   (a) Would the Ontario regulations apply regardless of the legal status of the federal regulation?

   (b) Would the Ontario Act operate in respect of those matters referred to as "exceptions" at page 4 of the Brief submitted to the Inquiry Commission by Labour Canada (attached)?

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5) Advise as to the steps which would have to be taken by (a) the federal government and (b) the provincial government to test the validity of the federal adoption of The Ontario Occupational Health and Safety Act, 1978 and regulations before the "appropriate" court as recommended at page 32 of the Staff Memorandum to the Members of the Select Committee on Ontario Hydro Affairs dated November 25, 1980. Further advise as to how long it would take to have the issue resolved by the "appropriate" court and whether or not such a resolution would be determinative for all purposes or whether the resolution could be appealed to a higher court in a subsequent case.

In addition, I would ask you to reply to the following questions:

1) What is the practical difference, if any, in terms of an employee's right to refuse unsafe work under s. 82 of the federal Code and s. 23 of the Ontario Act? In particular, I would ask you to address the difference, if any, between "reason to believe" and "reasonable cause to believe", and "likely to endanger" and "imminent danger". The predecessor bill for the Ontario Act contained a reasonable cause to believe test which was changed to a reason to believe test in the current statute. The Canada Labour Relations Board dealt with the meaning of "imminent danger" in Miller v. C.N.R., April 14, 1980. The Ontario Labour Relations Board has not had a case under the new Act although the OLRB dealt with the right to refuse under the predecessor bill in RE INCO, (1980) O.L.R.B. Rep. July 981 and in Re Canada Gypsum, (1978) O.L.R.B. Rep. Oct 897.

2) If the Inquiry Commission was of the view that the Elliot Lake uranium mine and plant workers should be covered by statutory language indentical to that covering other miners in the province, could such a result be achieved by incorporating the Ontario Act and regulations, as amended from time to time, directly into the Canada Labour Code and providing that, where the other provisions of the Code and the provisions pertaining to uranium miners are in conflict, the latter shall apply?

3) Could this result be achieved by repealing the regulation under the Canada Labour Code and passing a regulation under the Atomic Energy Control Act providing that, in matters of conventional safety, the provisions of the Ontario Act and regulations, as amended from time to time, apply to uranium miners working in the province of Ontario?

4) What requirements of the Statutory Instruments Act

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would have to be satisfied if either of the above alternatives were to be acted upon?

5) What other alternatives, if any, would lead to the same result?

I understand that you will be providing us with your opinion on or before January 8, 1981. I can be reached at the Inquiry office (965-0563) or at the Ontario Labour Relations Board (965-0200) if at any time you wish to discuss this matter.

Sincerely,

Kevin M. Burkett

LIST OF ATTACHMENTS

1) Memo prepared by the staff of the Inquiry Commission.

2) Brief submitted to the Inquiry Commission by Labour Canada.

3) Staff memorandum to the members of the Select Committee on Ontario Hydro Affairs dated November 25, 1980 - pages 9 - 36.

4) "Laskin Opinion" re "Canada Occupational Health and Safety Regulations for Uranium and Thorium Miners" dated August 29, 1980.

5) "Robinette Opinion" re "Legislative Jurisdiction with respect to Health and Safety of Ontario Uranium Miners".

6) "Ollivier Opinion" re "Canada Labour Code Application to Nuclear Industry".

7) E. A. Driedger, Q.C., "The Interaction of Federal and Provincial Laws", (1976) 54 C.B.R. 695.

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February 5, 1981

Kevin M. Burkett, Esq.
Joint Federal - Provincial Inquiry Commission
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Dear Mr. Burkett:

Re: Statutory Safety Protection for Uranium Miners and Mine Plant Workers in Elliot Lake

Your letter dated December 4, 1980 requested my opinion respecting certain issues and questions raised therein. Enclosed herewith is my opinion which addresses those issues and questions.

Yours faithfully,

Pierre Genest

PG:td

Enclosure

Re: Statutory Safety Protection for Uranium Miners and Mine Plant Workers

In your letter of December 4, 1980, you have requested my opinion respecting several questions relating to the validity, constitutionality, scope and interpretation of statutory safety protection for uranium miners and mine plant workers in Ontario. You have provided me with the following documentation:–

1) Memorandum prepared by the staff of the Inquiry Commission;

2) Briefs submitted to the Inquiry Commission by Labour Canada;

3) Staff memorandum to the members of the Select Committee on Hydro Affairs, dated November 25, 1980;

4) Opinion of Professor John B. Laskin, dated August 29, 1980;

5) Opinion of J. J. Robinette Q.C., dated December 27, 1978;

6) Opinion of P. M. Ollivier, Q.C., dated October 13, 1978;

7) Article by E. Driedger, ''The Interaction of Federal and Provincial Laws'', (1976) 54 C.B.R. 695.

I will consider in turn each of the questions you have asked. I will deal first with the five questions set out on page 2 of your letter of December 4, 1980.

1. *Review the ''Laskin Opinion'' and advise as to whether or not, in your opinion, reasonable grounds exist upon which to challenge the validity of the federal regulation.*

This question relates to the validity of the adoption by reference of The Occupational Health and Safety Act, S.O. 1978, c. 83 (an Ontario statute) and the Regulations for Mines and Mining Plants (Ontario Regulation 660/79) (being regulations promulgated under the above mentioned Act), as the Canada Occupational Health and Safety Regulations for Uranium and Thorium Mines SOR/79-636 as amended by SOR/80-409, promulgated pursuant to the Canada Labour Code, a statute of the Federal Parliament. The issue is whether the adoption by reference of the Ontario statute and regulation makes them ''statutory instruments'' subject to the registration and filing requirements of the Statutory Instruments Act, S.C. 1970-71-72,c.38.

While the provisions of the Statutory Instruments Act have been complied with in respect of the federal regulations which adopt by reference the Ontario law and regulations, the provisions of the Statutory Instruments Act have not been complied with or followed in respect of the actual Ontario legislation. Professor Laskin has concluded that this non-compliance renders these invalid and of no force and effect as a result of the provisions of section 9 of the Statutory Instruments Act. He is of the view that on the proper construction of the definition section of the Statutory Instruments Act the Ontario laws and regulations are themselves statutory instruments.

I should at the outset point out that the question you have framed in your letter of December 4, 1980, is not whether I agree with Professor Laskin's opinion but "whether or not . . . reasonable grounds exist upon which to challenge the validity of the federal regulations." I find it difficult to deal with your question as posed. As I will point out later, I am in disagreement with Professor Laskin's conclusion and am of the view that the federal regulation is valid, but I find it impossible to pass judgment on whether his considered opinion can be called unreasonable. I therefore propose to state the reason for which I disagree with Professor Laskin's conclusions, which in my view lead to an unreasonable result.

As I have stated, the central question is whether the adoption by reference of provincial legislation by federal regulation made under the authority of a federal statute has the effect of making not only the adopting federal regulation but the provincial legislation itself a "statutory instrument" requiring registration and filing not only of the adopting federal regulation but of the adopted provincial legislation as well. In other words, applying the language of section 2(1) (d) (i) of the Statutory Instruments Act, do The Ontario Act and regulations, once adopted by reference, constitute in themselves a "rule, order, regulation . . . issued, made or established . . . in the execution of a power conferred by or under an Act of Parliament by or under which such instrument is expressly authorized to be issued, made or established . . ."? It is my view that they do not.

It is my opinion that the reasoning set out in the first paragraph of page 4 of Professor Laskin's opinion constitutes a sensible interpretation of section 2(1) (d) (i) of the Statutory Instruments Act. It is my opinion that the Ontario Statute and Regulations cannot possibly be said to have been issued, made or established "in the execution of a power conferred by or under an Act of Parliament" within the meaning of section 2(1) (d) (i). As stated by Professor Laskin, the Occupational Health and Safety Act was enacted by the Legislative Assembly of Ontario pursuant to the constitutional powers conferred on the province by section 92 of the BNA Act, and the

regulations for mines and mining plants were made by the Lieutenant Governor in Council of Ontario pursuant to an Ontario statutory power. If this is so, it is my view that it is only the adopting regulation and not The Ontario Act and regulations which it adopts which satisfies the requirements of section 2(1) (d) (i) of the Statutory Instruments Act.

It is true that adoption by reference of provincial legislation as the safety and health standard applicable to federal works and undertakings within the province has the effect of making that provincial legislation a part of the laws of Canada but it does not follow, in my opinion, that such provincial legislation is thereby constituted a ''statutory instrument'' within the meaning of the Statutory Instruments Act.

I have no hesitation in stating that the Statutory Instruments Act is as opaque and obscure a piece of legislation as it has been my misfortune to study. Nevertheless, the statute must be construed and interpreted so as not to lead to absurdity, and each relevant section must be looked at to assist in ascertaining the intention of Parliament. In this connection, I am of the view that the provisions of sections 3, 4, 7, and 8 of the Statutory Instruments Act are all relevant in ascertaining whether it was the intention of Parliament that provincial legislation adopted by reference in a federal regulation constituted by itself a statutory instrument requiring filing and registration. I set out the relevant provisions of these sections:–

3.(1) Where a regulation-making authority proposes to make a regulation it shall cause to be forwarded to the Clerk of the Privy Council three copies of the proposed regulation in both official languages.

(2) Upon receipt by the Clerk of the Privy Council of copies of a proposed regulation pursuant to subsection (1), the Clerk of the Privy Council, in consultation with the Deputy Minister of Justice, shall examine the proposed regulation to ensure that

(a) it is authorized by the statute pursuant to which it is to be made;

(b) it does not constitute an unusual or unexpected use of the authority pursuant to which it is to be made;

(c) it does not trespass unduly on existing rights and freedoms and is not, in any case, inconsistent with the provisions of the Canadian Bill of Rights; and

(d) the form and draftsmanship of the proposed regulation are in accordance with established standards.

(3) When a proposed regulation has been examined as required by subsection (2), the Clerk of the Privy Council shall advise the regulation-making authority that the proposed regulation has been so examined and shall indicate any matter referred to in paragraph (a), (b), (c) or (d) of that subsection to which, in the opinion of the Deputy Minister of Justice, based on such examination, the attention of the regulation-making authority should be drawn.

(4) Subsection (1) does not apply to any proposed regulation or class of regulation that, pursuant to paragraph (a) of section 27, is exempted from the application of that subsection, and paragraph (d) of subsection (2) does not apply to any proposed rule, order or regulation governing the practice or procedure in any proceedings before the Supreme Court of Canada or the Federal Court of Canada.

4. Where any regulation-making authority or other authority responsible for the issue, making or establishment of a statutory instrument, or any person acting on behalf of such an authority, is uncertain as to whether or not a proposed statutory instrument would be a regulation if it were issued, made or established by such authority, it or he shall cause a copy of the proposed statutory instrument to be forwarded to the Deputy Minister of Justice who shall determine whether or not the instrument would be a regulation if it were so issued, made or established.

7.(1) Where any statutory instrument is transmitted or forwarded to the Clerk of the Privy Council for registration under this Act, the Clerk of the Privy Council may refuse to register the instrument if

> (a) he is not advised that the instrument was, before it was issued, made or established, determined by the Deputy Minister of Justice pursuant to section 4 to be one that would, if it were issued, made or established, not be a regulation; and
>
> (b) in his opinion, the instrument was, before it was issued, made or established, a proposed regulation to which subsection (1) of section 3 applied and was not examined in accordance with subsection (2) of that section.

(2) Where the Clerk of the Privy Council refuses to register any statutory instrument for the reasons referred to in subsection (1), he shall forward a copy of the instrument to the Deputy Minister of Justice who shall determine whether or not it is a regulation.

8. No regulation is invalid by reason only that it was not examined in accordance with subsection (2) of section 3, but where any statutory instrument that was issued, made or established without having been so examined

> (a) was, before it was issued, made or established, determined by the Deputy Minister of Justice pursuant to section 4 to be one that would, if it were issued, made or established, be a regulation, or
>
> (b) has, since its issue, making or establishment, been determined by the Deputy Minister of Justice pursuant to section 7 to be a regulation,

the Governor in Council, on the recommendation of the Minister of Justice, may notwithstanding the provisions of the Act by or under the authority of which the instrument was or purports to have been issued, made or established, revoke the instrument in whole or in part and thereupon cause the regulation-making authority or other authority by which it was issued, made or established to be notified in writing of his action."

In my respectful view, it is absurd to suppose that Parliament should have intended that provincial legislation validly enacted should be submitted for the examination provided for under sections 3 and 4 or to refusal of registration under section 7 or to revocation under section 8.

There are numerous examples of federal regulations which contain a qualifying or definitional reference to a provincial regulation or statute. Examples of these include: regulations establishing restricted flying areas by reference to definitions contained in provincial statutes (Aeronautics Act, Flight Restrictions, National, Provincial and Municipal Parks Order, C.R.C. 1978, c. 46, s. 2); regulations providing for exceptions to general rules where a course of conduct is contrary to the law of a province (Post Office Act, Sale of Undeliverable or Re-directed Mail Regulations, C.R.C. 1978, c. 1298, s. 13); powers to deliver liquor by mail where permitted by the laws of a province (Post Office Act, Special Service and Fees Regulations, C.R.C. 1978, c. 1296, s. 22). The practical effect of the view that reference to provincial legislation constitutes that legislation a statutory instrument would require the filing and publication of provincial legislation in every instance where it is incorporated or adopted by reference into federal law, even where the federal regulation does not identify the specific provincial statute concerned. I therefore find it difficult to conceive that a court would interpret the Statutory Instruments Act in a fashion which would render illegal all such regulations.

For these reasons, it is my view that the conclusion reached by Professor Laskin leads to unreasonable and impractical results and that a Court would prefer an interpretation that does not lead to these results.

In my view, the primary aim of the Statutory Instruments Act is the publication and exposure to scrutiny of federal delegated legislation and rule making. The essential feature of the federal regulations we are considering is the fact that they adopt certain provincial legislation. It is entirely consistent with the object of the statute that the action of federal authorities in adopting the laws of a province should be filed and registered in accordance with the Act, but it is not in my view necessary to the objective of the Act that the adopted legislation itself should require registration.

In summary, it is my opinion that the federal regulations adopting by reference The Occupational Health and Safety Act of Ontario and the Regulations for Mines and Mining Plants made thereunder have been validly promulgated and are not subject to attack on the ground that the adopted Ontario legislation and regulations have not themselves been registered under the Statutory Instruments Act.

2. *If such grounds do exist, (i.e. reasonable grounds upon which to challenge the validity of the federal regulations) advise as to what steps must be taken to legitimize the regulation.*

In answering this question I will not now deal with the issues raised in Questions 2, 3, 4 and 5 on page 3 of your letter, all of which deal with alternative methods for federal adoption of provincial legislation to uranium mine and plant workers, which of course can be included in the steps that "must be taken to legitimize the regulation".

It is plain, of course, that if it was determined that the Ontario legislation and regulations were a "statutory instrument" and therefore a "regulation" within the meaning of the Statutory Instruments Act, the regulation would have no force and effect until it is registered and published in the Canada Gazette. Therefore, the Statutory Instruments Act would have to be complied with.

To answer the question you asked, the steps which must be taken to legitimize the regulation are obviously the steps required to be taken under the Statutory Instruments Act. This would involve the drafting of a proposed regulation in substance re-enacting Regulations SOR/79-636 and SOR/80-409 incorporating the full text of the Ontario legislation and regulations desired to be adopted and the submission of such proposed regulation in three copies in both official languages to the Clerk of the Privy Council

pursuant to section 3(1) of the Statutory Instruments Act for examination by the Clerk in consultation with the Deputy Minister of Justice pursuant to subsection 2 of section 3. Thereafter, the steps set forth in sections 5, 6, 10, 11 and 13 of the Statutory Instruments Act involving transmission, registration, publication and distribution of the regulation would all have to be complied with.

3. *Review the December 1978 ''Robinette Opinion'' (attached) and advise as to whether or not, in your opinion, reasonable grounds exist upon which to challenge the conclusions reached in that opinion; that is, the concurrent operation of the Ontario statute in respect of uranium miners and mine plant workers.*

The issue raised here is whether the regulation of occupational health and safety in a federal undertaking is a matter of exclusive federal legislative jurisdiction or concurrent federal and provincial legislative jurisdiction.

Mr. Robinette in his opinion has concluded that legislative authority is concurrent subject to federal paramountcy in case of a conflict. You have enclosed in the material you sent me the opinion of Mr. P. M. Ollivier, Associate Deputy Minister of Justice who has expressed the view that federal jurisdiction is exclusive although in his opinion he states that the question is not entirely free from doubt.

I see little point in going over the ground gone over so thoroughly by Mr. Robinette in his opinion. Mr. Ollivier merely relies upon the case of *Commission du Salaire Minimum v. Bell Telephone Company* [1966] S.C.R. 767, and does not discuss the issue.

I am in complete agreement with the views expressed by Mr. Robinette in his letter of December 27, 1978 for the reasons given by him. I should bring to your attention, however, that on the question of concurrency of legislative authority in the field of general provincial health and safety regulations which do not purport to protect uranium miners from harmful radium exposure or purport to affect the construction, repair and alteration of the plant or works of a uranium mine or their use, Mr. Robinette says only that

''It can be forcefully argued that the province can make applicable to uranium mines general provincial health and safety regulations if they do not conflict with Dominion regulations.''

I take it from this statement that Mr. Robinette does not regard the question as concluded. I am of the same view. There is no specific authority

respecting the question of whether regulation of occupational health and safety of a federal undertaking is a matter of exclusive federal jurisdiction or concurrent federal and provincial jurisdiction. The most recent authority relating to the general question of the application of provincial legislation to federal undertakings is the decision of the Supreme Court of Canada in *Montcalm Construction v. Minimum Wage Commission* (1978) D.L.R. (3d) 641 which was decided concurrently with the delivery of Mr. Robinette's opinion, and which he would not have had an opportunity of considering. While this decision does not deal directly with the problem with which we are dealing, Mr. Justice Beetz (whose decision was concurred in by six other members of the Court) reviewed the tests to be applied in deciding whether jurisdiction is exclusive or concurrent in respect of federal works or undertakings. The test appears to be not one of categorization of the legislation but rather of the actual effect of the provincial legislation on the federal work. Mr. Justice Beetz adopts the test propounded by Mr. Justice Martland in *Commission du Salarie Minimum v. Bell Telephone Company (supra)* at page 772 where Mr. Justice Martland states:–

"In my opinion all matters which are a vital part of the operation of an interprovincial undertaking as a going concern, are matters which are subject to the exclusive legislative control of the federal Parliament within section 91(29)."

I wish to adopt Mr. Robinette's comment at page 4 of his letter where he states:–

"It may be difficult to distinguish between general provincial wage legislation and general provincial health and safety legislation in relation to employees in a federal undertaking. It might be said that both are a "vital part" of the operation of an interprovincial undertaking."

Mr. Robinette goes on to express the view that I have quoted above, viz. that it can be forcefully argued that the province can make applicable to uranium mines general provincial health and safety regulations if they do not conflict with Dominion safety regulations. In addition to the cases relied upon by Mr. Robinette, Mr. Justice Beetz offers some support for this position in a passing reference in his reasons in the *Montcalm* case. At 93 D.L.R. (3a), page 654 he states:–

"Thus, the requirement that workers wear a protective helmet on all construction sites including the construction site of a new airport, has everything to do with construction *and with provincial safety regulations* and nothing to do with aeronautics . . ." (emphasis added)

Thus, the trend of recent decisions appears to be in favour of concurrent jurisdiction in respect of provincial legislation of general application.

Therefore, it is my view that the Court would likely hold that, subject to the qualifications mentioned in Mr. Robinette's opinion, provincial health and safety standards of general application apply concurrently with federal regulation, to federal works and undertakings.

4. *If the concurrent operation of the provincial statute is beyond reasonable challenge,*

   (a) *Would the Ontario regulations apply regardless of the legal status of the federal regulation?*

My answer to this question, very shortly, is ''yes''. Given that there is concurrent jurisdiction, that federal and provincial legislation can exist side by side subject only to the paramountcy of federal legislation in cases of actual and direct operational conflict, the Ontario regulations would apply in all cases except where there was a conflict as aforesaid between the federal and provincial legislation.

   (b) *Would the Ontario Act operate in respect of those matters referred to as ''exceptions'' at page 4 of the Brief submitted to the Inquiry Commission by Labour Canada?*

The brief submitted to the Inquiry Commission by Labour Canada concludes that the Ontario law applies in respect of conventional non-radiation safety and health for uranium mine and processing plant workers with three exceptions which they describe as follows:–

(a) appeals from a safety officer adjudication under imminent danger withdrawal provisions in our case (i.e. uranium mining) must be made to the Canada Labour Relations Board instead of to the Ontario appeal authority;

(b) joint safety and health committees must be specifically imposed by the Minister under the federal code instead of being universally required as under the Ontario code;

(c) prosecutions, as a matter of practice, are undertaken by the Federal Justice Department rather than by law officers of the Province of Ontario.

As to exception (a), both section 82 of the Canada Labour Code and section 23 of The Ontario Act provide for an employee's refusal to work in certain dangerous circumstances. Under The Ontario Act (section 23(3))–

"A worker may refuse to do work or do particular work where he has reason to believe that . . . (he or another worker is likely to be endangered by a variety of described causes)."

The Ontario Act goes on to prescribe certain administrative investigative and appeal procedures. The Canada Labour Code, section 82.1(1) provides that–

"Where a person employed upon or in connection with the operation of any federal work, undertaking or business has reasonable cause to believe that
(a) the use or operation of a machine, device or thing would constitute an imminent danger for the safety or health of himself or another employee or
(b) a condition exists in any place that would constitute an imminent danger to his own safety or health,
that person may refuse to use or operate the machine, device or thing or to work in the place."

The Canada Labour Code also provides its own administrative and appeal machinery.

Given that both statutes operate concurrently, it is my opinion that the provincial legislation will only be inoperative if it is in actual conflict with the federal legislation so that compliance with the provincial law entails a breach of the federal law. As is evident from a reading of the two statutory provisions, the Ontario legislation likely establishes a wider basis for an employee's right to refuse work than that provided in the federal Code. As there is nothing constitutionally offensive in the provincial legislature setting an equivalent or higher standard than that contained in federal legislation, (the *Montcalm* case *(supra)* at page 661) I am of the opinion that both standards remain in operation and that consequently the inspection and appeal provisions in both statutes are concurrently applicable. This legal conclusion leads to a potentially clumsy practical result which must be solved by federal-provincial co-operation.

With respect to exception (b) relating to joint safety and health committees, the provincial legislation universally requires joint safety and health committees, while the federal Act requires specific action by the Minister.

Again, it is my opinion that both the Ontario legislation and the federal legislation are operable, with the practical result that a joint health and safety committee would be required in every instance.

With respect to exception (c), relating to prosecution, the situation depends on whether the federal regulation adopting provincial legislation is valid or not. If such adoption is invalid, the regulations have no existence as federal regulations and federal prosecutors may only proceed in respect of violations of the Labour Code and not of the regulations. In that event, provincial authorities would have the right to prosecute for a breach of the provincial law.

If the federal regulations are valid, we have a situation where due to the concurrent operation of both federal and provincial enactments a breach of the provincial enactment constitutes a breach both of the federal and the provincial law and there is no reason why prosecutions could not be instituted under the current Labour Code by federal prosecutors or under the Ontario Act by provincial prosecutors.

5. *Advise as to the steps which would have to be taken by (a) the federal government and (b) the provincial government to test the validity of the federal adoption of* The Ontario Occupational Health and Safety Act, *1978 and regulations before the "appropriate" court as recommended at page 32 of the Staff Memorandum to the Members of the Select Committee on Ontario Hydro.*

The staff memorandum to the members of the Select Committee on Ontario Hydro, referred to in the above question, recommended that the Government of Canada and failing it, the Attorney General of Ontario should "take all steps necessary to test the validity of the federal adoption of The Ontario Occupational Health and Safety Act and regulations and in particular to bring the issue before the appropriate court".

As to the federal government, the most expeditious way of proceeding would be by way of a reference to the Supreme Court of Canada by the Governor General in Council under section 55 of the Supreme Court Act, R.S.C. 1979, c. S-19. This section permits direct reference by the Governor in Council to the Supreme Court of Canada of any "important question of fact or law" and the section further provides that any question referred by the Governor in Council, "shall be conclusively deemed to be an important question".

The procedural requirements of such a reference involve the passing of an Order-in-Council directing the reference and thereafter the rules of the

Supreme Court apply. Interested parties would be directed to file factums and the case set down for hearing in the usual way. Barring a special direction by the Court to expedite the hearing, the case would take its normal place on the list, and while it is difficult to be precise about the time that would be involved from the date of the reference to the date of argument, in my experience, such a reference would take anywhere from six months to a year to be finally disposed of, allowing a reasonable time for the Court to deliberate and deliver judgment. The judgment of the Supreme Court on the issue would be final and determinative of the issue for all practical purposes.

With respect to provincial action, since a province does not have the right to refer questions directly to the Supreme Court of Canada, the most expeditious way for provincial authorities to proceed would be under the Constitutional Questions Act, R.S.O. 1970, c. 79 which provides that the Lieutenant Governor in Council of the Province may refer to the Court of Appeal " . . . any matter for hearing and consideration". Once an Order-in-Council had been passed by the Lieutenant Governor of the Province, again the rules of the Court of Appeal with reference to the disposition of the appeal would take over; parties would be required to file statements of fact and law and the appeal would be set down in the ordinary course. The Court of Appeal is a little faster in disposing of appeals than is the Supreme Court of Canada because of its greater manpower and such a reference might reasonably be expected to be heard and disposed of in approximately four to eight months.

Any judgment delivered by the Court of Appeal of Ontario under a reference is appealable to the Supreme Court of Canada (Supreme Court Act, s. 37) and if an appeal is taken, the case would be involved in the ordinary processes of the Supreme Court of Canada and would probably take another year to be disposed of. Even if an appeal is not taken, a judgment of the Ontario Court of Appeal would not be finally determinative of the question because it is always liable to be upset by a judgment of the Supreme Court of Canada in another proceeding.

There is a further alternative way of proceeding pursuant to section 23 of The Judicature Act of Ontario where the Attorney-General for the province may commence an action against the Attorney-General of Canada for a determination of the validity of the regulations. I would not recommend this procedure as it is the slowest of all. Such a proceeding would be heard before a single judge of the High Court, and would be subject to appeal to the Court of Appeal of Ontario and from there to the Supreme Court of Canada.

I now pass to the consideration of the questions set out on page 3 of your letter of December 4, 1980 which I will number consecutively from those set out on page 2 of your letter.

6. *What is the practical difference, if any, in terms of an employee's right to refuse unsafe work under s. 82 of the federal Code and s. 23 of The Ontario Act?*

I have already set out the provisions of the two statutes in question in my answer to question 4 above. In my opinion, there is no substantial difference in meaning between "reason to believe" which is the expression used in the Ontario statute and "reasonable cause to believe" which appears in the Canada Labour Code. Under either provision, it is my view that a Court or a Board would require an employee to have an honest belief in the "likelihood" (Ontario Act) or "imminence" (Federal Labour Code) of the danger and that the belief was one which a reasonable person could have in the circumstances.

On the other hand, I am of the view that the standard set by "imminent danger" as opposed to "likely to endanger" is significantly different. The Shorter Oxford Dictionary defines "imminent" as "impending threateningly, hanging over one's head, ready to overtake one". The word "imminent" thus connotes a temporal immediateness to the danger, as well as a near certainty of the danger actually being present. On the other hand, "likely" is defined in the same dictionary as "having an appearance of truth or fact; seeing as if it would happen, or prove to be as stated; probable". Thus, it is my view that "likely to endanger" only necessitates proof of a probability of the occurrence of the danger, and contains no requirement as to the immediateness of the danger.

The case of *Miller v. C.N.R.*; a decision of the Canada Labour Relations Board, dated April 14, 1980, is referred to in your letter. The definition of "imminent danger" is discussed in the Reasons of the Board at pages 17 and 18 and is entirely consistent with the interpretation I have given above.

Apart from this decision, neither phrase appears to have received interpretation in Canadian Board or Court jurisprudence. However, both the expressions, "imminent danger" and "likely to endanger" have received interpretation in the American Courts which is also in accordance with the opinion expressed above. For example, see with respect to "imminent danger" *Coffin v. Blackwell*, 199 P. 239 and *State v. Smith*, 71 P. 973; and with respect to "likely" *Boland v. Vanderbilt*, 102 A. 2d 362 and *Garrard v. Manufacturers' Cola and Coke Company*, 104 S.W. 767.

7. *If the Inquiry Commission was of the view that the Elliot Lake uranium mine and plant workers should be covered by statutory language identical to that covering other miners in the province, could such a result be achieved by incorporating the Ontario Act and regulations, as amended from time to time, directly into the Canada Labour Code and providing that where the other provisions of the Code and the provisions pertaining to uranium miners are in conflict, the latter shall apply?*

The answer to this question is, in my opinion, clearly "yes". The authorities indicate that there is no constitutional objection to incorporation by reference of statutes of a province as they may exist from time to time. (see (Hogg, *Constitutional Law of Canada*, (1977) p. 228; *Coughlan v. Ontario Highway Transport Board* [1968] S.C.R. 569; *Attorney General of Ontario v. Scott* [1956] S.C.R. 137).

In my view, the effect of such an incorporation would be that uranium mine and plant workers would be covered by provisions identical to those covering other miners in the province. Furthermore, any possible difficulty respecting the Statutory Instruments Act is obviated as the provincial enactments are incorporated directly into the statute. Therefore, none of the requirements of the Statutory Instruments Act would have to be satisfied.

8. *Could this result be achieved by repealing the regulation under the Canada Labour Code and passing a regulation under the* Atomic Energy Control Act *providing that, in matters of conventional safety, the provisions of the Ontario Act and regulations, as amended from time to time, apply to uranium miners working in the Province of Ontario?*

In my opinion, the Atomic Energy Control Act is wide enough to permit the enactment of safety regulations. Because section 80(1) of the Canada Labour Code makes the provisions of Part 4 of the Code subject to any other act of Parliament or regulations thereunder, any safety regulations adopted under the Atomic Energy Control Act would prevail over the provisions of the Canada Labour Code. Aside from this, I see little practical advantage in transferring the incorporation of provincial legislation from a regulation passed under the authority of the Canada Labour Code to one passed under the Atomic Energy Control Act and in fact I would recommend against such a course because, as will be seen by my answer to the next question, this option results in one still being faced with the possible controversy respecting the application of the Statutory Instruments Act to provincial legislation adopted by reference in a federal regulation.

9. *What requirements of the* Statutory Instruments Act *would have to be satisfied if either of the above alternatives were to be acted upon?*

   As I have indicated above, if the Ontario Act and regulations are incorporated by reference directly into the Canada Labour Code, no question of compliance with the Statutory Instruments Act arises since such compliance is not necessary because it applies only to delegated legislation and not to acts of Parliament.

   As to requirements of the Statutory Instruments Act, if regulations are promulgated under the provisions of the Atomic Energy Control Act, one is still faced with the possible controversy respecting the application of the Statutory Instruments Act to legislation adopted by reference. If my view of the matter is correct, it is only the regulation passed under the Atomic Energy Control Act which adopts the provincial legislation which would have to comply with the requirements of the Statutory Instruments Act. All the requirements of that Act would apply.

   If Professor Laskin's view is the correct one, then the steps described in my answer to question 2 would have to be complied with. This, however, raises a difficulty. What would have to be filed, registered and published under the Statutory Instruments Act would be the Ontario legislation in existence at the time of the passing of the federal regulation. I have some doubt if the Statutory Instruments Act does in fact apply and as to whether the federal regulation would be effective in making future amendments to Ontario law a part of federal law, without the promulgation of a federal regulation each time the provincial law is amended.

10. *What other alternatives, if any, would lead to the same result?*

   I have no alternatives to suggest which have not already been discussed above. The most effective of these is the amendment to the federal Labour Code discussed under question 7 above.

I hope that I have sufficiently addressed the questions you directed to me, but if clarification is needed, do not hesitate to communicate with me.

Yours faithfully,

Pierre Genest

Harry Shannon, Assistant Professor
Occupational Health Program
McMaster University

Statistical data on mining accidents in Ontario

January 1981

The Commission retained Harry Shannon, Assistant Professor, Occupational Health Program, McMaster University to up-date the statistics produced in the Report of the Royal Commission on the Health and Safety of Workers in Mines – 1976, and to report on the accident data base in the Ontario mining industry. Professor Shannon holds a Ph.D. in statistics and has specialized in the area of occupational health and safety statistics. His thesis was on A Statistical Study of 2,500 Consecutive Reported Accidents in a Automobile Factory. Dr. Shannon obtained his Ph.D. at the University of London, England.

The Commission was interested in the general state of mine accident statistics and asked me to examine this and suggest any modifications that might be made. There are several issues involved. What information is collected? For which accidents are data obtained? Who collects the information? Who uses it and for what purposes?

In answering this question I have had discussions with various individuals, both producers and users of data. In addition, I have read papers and articles examining the issue. Since many of the ideas I will cover were raised by more than one person I shall not specifically acknowledge each one's contribution. Nevertheless, I am deeply indebted to these people, who so readily gave their time and helpful advice.

An obvious starting point is to examine the reasons that data on accidents are collected. There are several of these, which may or may not overlap. The major purposes that I have identified are:

a) To measure accident performance
We may want to know the extent to which accidents occur, whether the rate is rising or falling, whether particular individuals or groups are at high risk, etc.

b) To identify causes and errors
For each accident we want to know the cause (machine failure, lack of training, etc.) and whether any error (in a broad sense) occurred. Failure of management and supervisor are included.

c) To check on control
There may sometimes be an apparent method of eliminating or reducing a particular hazard; but because of unforeseen problems safety precautions may not prove adequate. We can check on this by determining if certain types of accidents or injuries are less common after the implementation of the safety measures.

d) As a basis for expertise
Knowledge of a wide range of accident situations and the circumstances in which they arise will provide safety professionals with the expertise they need for advising on accident prevention.

Other purposes, such as research, may not be fully covered by these four, but I do not believe that allowance for this would change what I shall discuss.

The first of these aims is one that requires merely a count of accidents and a measure of the risk (either person-years or hours of work in the occupational group). Rates can then be calculated and compared across jobs or trends with time examined.

Such data should be simple and straightforward to collect. Before discussing them further I will note that accident forms in practice contain more information which can be used for the other purposes listed above. This, of course, means that details irrelevant to the aim of measuring performance are collected. I shall discuss this point later.

To return to the estimation of accident rates: as I stated above, this should create no problem. All that is needed is a consistent definition of an accident and reports from companies on the number of hours worked but consider the data in Table 1 from 3 different sources:* (a) The 49th Annual Report, May 1980 of the Mines Accident Prevention Association of Ontario (MAPAO); (b) The Brief, to this Commission of the Ministry of Labour (Brief 1); (c) The Brief to the Select Committee on Ontario Hydro Affairs of the Ministry of Labour (Brief 2). The numbers of fatal accidents in Ontario mines for each year from 1976 to 1979 is shown–in no case do any two of the three sources yield the same figure. The reasons are several. The discrepancy in the Ministry figures is due to the fact that the jurisdiction of the Mines Health and Safety Branch is broader than might be implied by the term ‘Mines’. Included are open pits and quarries, as well as oil drillings. (Fortunately, at least for these purposes, the latter is a relatively small category in the Province.) The Ministry of Labour’s Brief 2 included deaths that occurred in open pits and quarries, while these were excluded in their Brief 1, since this Commission’s scope does not include the open pits and quarries. The reason for the difference with the figures in the MAPAO’s Annual Report is unclear. The legend to the table is ‘Review of Injury Experience in Class 5’. Class 5 is a categorization used by the Worker’s Compensation Board which comprises all mining companies (mining, reduction, smelting and treatment plants) as well as diamond drillers and mining contractors. Although a footnote points out that Class 5 Rate 940 (mining consultants) is excluded, the numbers of hours worked are almost identical to (actually very slightly lower than, except for the provisional 1979 data) those given in the Ministry of Labour’s Brief 1, and yet the numbers of fatal injuries differ. Moreover, the difference is not consistent–for three of the years the MAPAO numbers are lower than those in Brief 1, but for 1977 the MAPAO recorded *more* fatalities.

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*See page 184

I chose this example of the difficulties of obtaining one consistent set of data on mining injuries because one expects that there should be little doubt about the number of fatal injuries occurring. This is not so. The problems are even greater when one examines the number of injuries. Industrial diseases (silicosis, hearing loss, etc.) may be included in some sets of data, but not in others. An injury may not lead to time lost from work (beyond the day of the accident), but if it produces medical costs it will be reported to, and included in the figures of, the Workmen's Compensation Board (WCB). Lost time accidents will clearly exclude such injuries.

Difficulties may also arise in assessing trends over time if there are changes in the legal definitions of lost-time or compensable injuries. However, since the current criteria have been used for roughly 10 years and are unlikely to change I do not see this as a potential problem.

I have so far considered only the numerators of various rates that may be calculated. Even if the population is defined, there are other difficulties in assessing the denominators. For example, the Workmen's Compensation Board uses only the assessable payroll to estimate the numbers of hours worked. However, earnings over the insurable limit of $18,500 per annum are ignored and since many miners, especially those earning high bonuses, are paid substantially more than the limit the estimates of number of hours worked will not be the 'true' ones. On the other hand, companies keep records of actual hours worked and apparently report these to MAPAO (who, however, use WCB estimates in their annual report, presumably for comparability. Professor Weiler, in his recent report *Reshaping Workers Compensation for Ontario*, recommended a large increase in the maximum compensable annual wage, from $18,500 to $40,000 with regular future adjustments. Whilst this will probably reduce or eliminate the discrepancy there seems to be no reason why actual hours of work should not be used.)

It would be possible to continue in this vein. There is, though, little to be gained from this. I hope I have demonstrated the current problems of definition in assessing accident performance.

In general, it can be said that for those accidents which are counted, the various bodies using the data know a good deal about the accident victims, but little about the remaining miners. Yet to fulfill one of the primary objectives of measuring accident performance–identifying high-risk groups–we need information on the latter. For example, we may know from accident data that 50% of injuries occur to miners under 30, but we will draw a very different conclusion if we are told that 25% of miners are in this age-group than we would if 75% were. However, such information is not

available (unless a specific survey is made of every mine). Thus a second problem has been identified–the lack of detailed baseline (or denominator) data, with which to estimate rates of accidents for sub-groups of the mining population.

These are difficulties encountered when accident data are used to measure performance. The three other purposes of data collection noted earlier–identifying causes and errors, checking on control and providing a basis for expertise–can be linked by the fact that rather than requiring data on the number of accidents and characteristics of the victims they demand information on the nature and manner of occurrence of the accidents themselves.

Almost all such data are currently obtained through the WCB using the 'Form 7' which is the 'Employer's Report of Accidental Injury or Industrial Disease' which, by law, must be filed ''within three days of learning of an occupational injury or disease that disables an employee or requires medical aid.'' The form takes up one side of an ordinary sized sheet, the reverse side being used mainly for explanatory details. The major purpose of the form is to provide enough information to judge the compensation claim, although some additional questions are asked. Those dealing with the accident occurrence itself were recently changed to elicit extra description of what happened. Whilst the nature of the questions will play a large part in determining the quality of the information, the limited space must also be an essential factor–and that space is limited because of the major function of the WCB: payment of compensation to injured workers. The Board believes, and I agree with their view, that any increased complexity in the form would delay its return and hence delay payments. This would counteract the underlying philosophy of Worker's Compensation in the province, that by adopting a no-fault insurance scheme the delays associated with civil litigation that would increase the victim's suffering can be avoided.

Professor Weiler, in his report, suggested that accident prevention was a major, if not the most important, function of the WCB–he argued that the justification for maintaining a no-fault insurance policy for occupational accidents (rather than adopt a universal insurance scheme) was to be able to collect information on this subgroup of accidents to use for prevention. Insofar as a portion of companies' assessment for workers' compensation is paid to the relevant safety associations, e.g., MAPAO, the WCB *is* involved in prevention. However, this work uses only a small proportion of premiums and the associations appear to be effectively independent of the Board.

One problem of data collection, then, is the (lack of) extensiveness of information on accidents. A second relates to that which might be obtained, with or without constraints on the size of any form: as noted earlier, the nature of the questions asked will in large measure determine the quality of the data obtained: they provide descriptive information about hazards of mining. The 'Form 7' mentioned earlier is not designed to provide great detail–rather it is intended to enable adjudication of compensation claims. Nevertheless, its recent modification has increased the amount and, I believe, quality of data being requested. Another recent improvement is that the details are coded using a widely recommended classification system–that adopted by the American National Standards Institute. This enables various aspects of the accidents to be cross-tabulated, providing a better quantification of where problems may exist or continue to occur. It should be noted, though, that the questions asked are general ones and are not aimed specifically at mining accidents.

A further question that needs to be addressed is: who should collect, analyse and disseminate the data? Should it be the Mines Health and Safety Branch, who have administration and enforcement duties; the WCB who must use the information to pay compensation; the MAPAO, who are concerned with prevention of further injuries; perhaps another body; or a combination of the organizations?

Having discussed the nature of the current data base and described some associated problems, I shall now suggest some modifications which I hope would further improve the situation.

A primary requirement is to provide clear and unambiguous definitions of what accidents are to be included in the statistics produced. This includes the need to define an accident, the minimum severity of the accident, the occupational categories covered and the time frame involved.

For the first of these, it is important to ensure that traumatic injuries only are included. Claims for hearing loss, 'white-finger' and other diseases should of course be reported, but separately. Regarding the minimum severity of the accident, I believe there are two reasonable possibilities: (a) all accidents for which the Board makes a compensation payment (this includes accidents requiring medical aid and those resulting in absence from fully paid work beyond the shift on which the accident occurred); or (b) all those accidents in (a) as well as those which necessitate the employee to perform modified work beyond the shift on which the accident occurred. I would favour the latter because, although it involves additional work, it would enable a better comparison of the performance of different sectors of

the industry–some companies have more comprehensive schemes than others and might 'hide' injuries by enabling injured workers to work, at full pay, in a light-duty job. (It should be recognized that under-reporting might occur–and, if it did so to any marked degree, would obviate the intented effect.)

I do not think it is useful for me to define the occupational categories to be included. What is important is that any statistics produced should clearly state which groups are covered, e.g., whether open pits and quarries are counted as 'mines'. Moreover, since reports may be read or used by those without much familiarity with the industry, jargon terms–such as 'Class 5'–should be avoided as far as possible.

For the time frame involved, I favour the practice of the WCB who count accidents by the date on which compensation is first paid. Whilst this may initially seem inferior to using the date of the accident itself (especially for those injuries occurring at a year's end) it will avoid problems resulting from any delays in reports' reaching the Board. There are some instances in which payment is not made for several years after the accident, so unless changes are made to previously published reports these injuries will never be incorporated into the statistics if the date of the accident is used. The proportion of claims paid long after the accident occurs is very low, however, and will affect the statistics very little. Nevertheless, their inclusion at some stage is essential to a comprehensive reporting system. I am also not concerned by the possible errors that may occur with accidents occurring at the end of the year. These will almost certainly balance each other out and thus not affect the rates to any extent. (Moreover, if trends over time are to be examined, this problem becomes irrelevant.)

It was noted earlier that the reports of accidents provide a good deal of information on claimants but that little has been collated on the mining population as a whole. The information is undoubtedly available in the personnel records of individual companies: all that is seemingly required is that it be brought together by an appropriate agency. I believe that to do this will in future become easier and easier. Small computers are now very cheap and I doubt if even small businesses, let alone mining companies, will not be using them within a very few years. The information that would be relevant to calculating rates and identifying high-risk sub-groups on miners, such as age, occupation, hours worked, is generally kept by personnel departments and used for payroll purposes (and as a former colleague, who frequently used company files for epidemiological studies, was fond of saying: "Wherever money changes hands, there are good records.") Provision of such data need demand the minimum of effort from a

company. All that is needed is a copy of a computer tape with the relevant information on individual miners–of course, precautions regarding confidentiality must be taken.

Turning now to the data that are collected–I noted earlier that there have been changes (in my opinion, improvements)–to 'Form 7', the major source of information on mining accidents, and that it was unreasonable to expect the WCB to extend their form. Nevertheless, this does not always get at the real cause(s) of the accident and there is much to be gained from devising a reporting form specifically for mining accidents, to be used by those concerned with prevention. At least initially, this might be completed on a sample basis only, or for accidents above a certain level of severity. There is a precedent for this. The Construction Safety Association of Ontario (CSAO) designed a short questionnaire to elicit 'accident causal data.' The CSAO's corresponding organization, the MAPAO might take on this task. (Ministry of Labour inspectors currently complete a computer-coded form which attempts to probe into the underlying, as well as contributions, cause(s) of the most serious injuries. However, the proposed form would be completed for a larger proportion of the accidents.)

It is, of course, pointless to acquire such data without systematic methods of analysis that are routinely conducted. Development of such procedures should accompany the design and use of the form.

Who, then, should collect the data, analyse it and distribute the resulting tabulations? There seems to be little point in changing the current practice with 'Form 7' which is initially sent to the WCB, who pass on the information to the Mines Health and Safety Branch and the MAPAO. Because the submission of the report is legally required, there is believed to be minimal under-reporting; and since claims are adjudicated, only truly occupational accidents are included.

Various organizations currently analyse these data–and produce different figures because they adopt different criteria. I understand that, through the Ministry of Labour, a working group representing several relevant parties in grappling with the problem of standardizing these criteria. I believe this is essential, and have stated above some definitions I would adopt. I would also suggest that much of the duplicated (or even triplicated) effort should be avoided. Two possibilities exist:

a) *The working group might agree on the analyses to be carried out by each party involved, who would share their findings with the others. An advantage of this is that each organization can concentrate on its*

own area of interest. For example, the WCB would calculate accident performance in the rate groups to assess premiums to be paid by each company, whilst the MAPAO would focus on causes of accidents.

b) *The alternative is for all analyses to be conducted in one place–the most appropriate being within the Research Branch of the Ministry of Labour. Other agencies would be routinely supplied with analyses of data and could request* ad hoc *tabulations to answer specific questions.*

On balance I favour this approach, since it will prevent the confusion and discrepancies resulting from separately performed analyses. Moreover, the Research Branch is a relatively independent agency that can produce good quality data–and this would be emphasized by the accummulation of expertise on the subject. I believe they could (and should) also respond better to requests from 'outsiders' who may have legitimate reasons for seeking particular information. Of course, if the data are analysed by one agency, then the question of who should disseminate the information is answered.

I should stress that these comments refer to the basic data generated by 'Form 7'. Clearly other information, such as that obtained through the proposed forms seeking underlying cause, is most appropriately analysed by the agency responsible–in the example used, the MAPAO.

Before concluding, I shall report a comment made to me while I was at the Ministry of Labour. Apparently, one of the Ministry's staff, frustrated by the discrepancies in, and differences in the scope of, statistics produced, exclaimed "what this place needs is a Data Czar." Whilst this story may be apocryphal, I have a good deal of sympathy with the sentiment. However, at the risk of sounding like a party to the constitutional debate, I should say that I believe it is important that some measure of agreement be reached by the agencies involved regarding the criteria and definitions on which the statistics are based.

Finally, I have discussed the three steps–collection, analysis and dissemination of data. It is easy to forget the fourth and most important step–application. If statistics are to help in preventing accidents, their message must be translated into practical action.

Table 1

Fatal accidents (and rates) in Ontario mines 1976-79 reported in 3 documents

	Year			
Document	**1976**	**1977**	**1978**	**1979**
MAPAO Annual+ Report 1980	19(0.23)	16(0.20)	8(0.13)	5(0.08)
Min. Labour Brief 1*	22(0.28)	13(0.17)	12(0.19)	9(0.16)
Min. Labour Brief 2†	25(0.27)	14(0.16)	17(0.23)	11(0.16)

+ Table on p. 11 of report of Mines Accident Prevention Association

* Table 2, p. 7 of Brief to this Commission, Nov. 20, 1980.

† Table 2, Appendix 2, of Brief to the Select Committee on Ontario Hydro Affairs, July 23, 1980.

Notes:

1. See text for explanation of differences.
2. Numbers of deaths shown with rates per million hours worked in parentheses.

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